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Vol. 18 No. 2 APRIL 1956

THE

Progressive Fish-Culturist

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THE

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TABLE OF CONTENTS

	Page
Walleye Pond Management in Minnesota -- John Dobie	51
Histopathology of Fish: III. Peduncle ("Cold-Water") Disease -- E. M. Wood and W. T. Yasutake	58
A New Mechanically Adjustable Multi-Size Fish-Grader -- K. E. Morton	62
Some Cytological Observations on Fish Erythrocytes -- George J. Ridgway	67
Beaver-Trout Relations in New Mexico -- William S. Huey and William H. Wolfrum	70
Lignasan for Bacterial Gill Disease -- Robert R. Rucker, Brian J. Earp, and Roger E. Burrows	75
Use of C M U To Control Najas -- Norman G. Benson and J. T. Conner	78
The Success of a Seine in the Sampling of a Largemouth Bass Population -- C. W. Threinen	81
Incidence of B-Complex Avitaminosis Among Common Carp Reared in Troughs -- A. R. K. Zobairi	88
Harvest From an Experimental One-Acre Salt-Water Pond at Bears Bluff Laboratories, South Carolina -- G. Robert Lunz	92
Migration Behavior of a Dwarf Sucker With an Injured Brain -- Wilford A. Dence	95
Items	
Diets for Chinook Salmon	57
A Practical Ice-Auger for the Fishery Biologist	66

Items (continued) Page

Eye and Behavior Differences ---------- 69
Yellowfin Tuna in Cold and Warm Water ---------- 80
Advanced Training Course for Aquatic Biologists ---------- 87
Improved Pliers for Applying Ring Tags ---------- 91
Treatment of Trichodinid Infections of Chinook Salmon Fingerlings ---------- 94
Trout and Grayling Populations in Grebe Lake ---------- 96

WALLEYE POND MANAGEMENT IN MINNESOTA

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Minnesota Department of Conservation
St. Paul, Minnesota

MINNESOTA'S WALLEYE POND MANAGEMENT has two goals. First and foremost is the production of enough walleye fingerlings to stock all of the State's lakes that need stocking with this species. The second goal is the production of enough large fingerlings for therapeutic stocking. In order to achieve these goals a system of checking the ponds and the method of increasing the food supply had to be devised.

The Problem

A study of the drainable walleye ponds showed a close relationship between the percentage of organic matter in the pond soil and the amount of fish produced in each pond. (See table 1.)

The ponds with less than 4.0 percent organic matter occasionally produced good crops of fish but usually were consistent in producing very few fish. Plankton samples and analyses of stomachs of the fish from these ponds showed that starvation and cannibalism in midseason were generally the important factors causing the decrease in the fish population.

The ponds with fertile soils were consistent in producing good fish crops. The few failures were usually due to deficiencies in the operational procedures and could be traced to predation by aquatic insects or to summerkill that resulted from the decomposition of large algal blooms.

This information indicated that the problem must be approached from two angles. First, the fertilization program had to be altered so as to build up the infertile soils and increase the midseason food supply. Second, a method of checking the ponds that was accurate enough to show when the fish were in danger of starvation or suffocation had to be devised.

TABLE 1.--Organic matter in pond soil and fish production in each type

Soil type	Percentage of organic matter	Fish production (pounds per acre-foot)[1] in 1953
Sand---------	1.1	0.1
Loamy sand---	2.5	1.3
Silt loam----	15.7	5.0
Sandy loam---	8.9	9.4
Clay loam and silty clay loam-------	7.7	16.9
Sandy clay---	3.2	1.6

[1] Pounds per acre-foot x 2.8 = pounds per surface acre, approximately.

Pond Fertilization

Prior to 1953, the ponds were fertilized with barnyard manure or dried sheep manure on the basis of the fertility of the water in each pond. All of the fertilizer was put into the pond in one application before the pond was filled with water. The resulting fish production was very spotty. Under the new system, the ponds were still fertilized with organic fertilizers, but the rate was based on the fertility of the bottom soils. In order to lessen the danger of summerkill, the fertilizer was

TABLE 2.--Organic matter in pond soil and nitrogen applied as fertilizer in each type during the season

Soil type	Percentage of soil organic matter	Nitrogen fertilizer (pounds per season per acre-foot)
Sand---------	1.1	7.0
Loamy sand---	2.5	6.0
Sandy loam---	8.9	4.0
Silt loam----	15.7	4.0
Clay loam and silty clay loam-------	7.7	4.0
Sandy clay---	3.2	7.0

applied on four dates during the season. The actual rate for each pond was based on the data in table 2. Half of the nitrogen (table 2) was added as barnyard manure before the pond was filled with water, and the other half was added as dried sheep manure in three applications during the first half of the summer. Samples of each batch of barnyard manure were sent to the St. Paul laboratory for nitrogen analysis. The amount of manure for each pond was calculated on the percentage of nitrogen shown in the tests. Phosphorus was not tested because previous work had shown that the manures contain enough for good bacterial action.

Available information indicated that these rates of fertilization were close to the maximum that the ponds could utilize without producing a summerkill. At the same time, it was apparent that the ponds with infertile soils were not getting enough organic matter to insure a good production of food organisms in midseason. Consequently, the ponds with sand, loamy sand, and sandy clay soils were put on a program of dry-fallowing. The first summer each of these ponds was drained and harvested early so that the soil could be disked and fertilized with 300 pounds of 10-10-10 fertilizer per acre and the entire bottom could be planted with 75 pounds of rye per acre. As a safety measure the following spring, fertilization with barnyard manure was eliminated; but summer applications of dried sheep manure were continued unless the ponds showed signs of developing conditions adverse to fish life.

Pond Checks and Evaluation

In order to prevent fish losses in the ponds and to determine the time and cause of the losses that do occur, it is necessary to check the ponds thoroughly and often. The fish culturist in charge of a group of ponds visits each pond at least once a week and checks the water temperature, dissolved oxygen, and plankton

BF Form 136
(Rev. 3-11-54)

WEEKLY WALLEYE POND SURVEY

Pond_____ Pond level reading_____

Date_____ Time of day_____

Water temperature

Pocket thermometer_____ °F.
Maximum_____ °F.
Minimum_____ °F.

Dissolved oxygen at surface_____ p.p.m.
at 4 feet_____ p.p.m.

1,000 ft. tow net sample_____ ml. algae
_____ ml. crustaceans
_____ ml. scuds
_____ ml. insects
_____ ml. silt

Test seining

Number walleyes collected_____ Number sent in_____
Area seined_____ square feet
Average length of walleye_____ inches
Number of fish per pound_____

Water sample (10 places)_____

Soil sample (10 places)_____ Location_____

Notes:

Collected by:_____

Title:_____

District Supervisor:

_____

FIGURE 1.--Form prepared for each pond collection.

crop. The plankton crop is measured by treating a tow-net sample with chloroform to make the organisms heavy enough to settle to the bottom of a graduate. The volume is then recorded as milliliters of organisms per 1,000-foot tow (Dobie 1951). The fish culturist also collects a composite water sample, a soil sample, and six fish, which are sent to the St. Paul laboratory by the first express. He fills in a Form 136 (figure 1) for each pond collection. The fish culturist is asked to measure and weigh the fish before shipping them, so he is able to keep a record of their growth. At the end of each day his records are complete except for the results of the water and stomach analyses.

In the St. Paul office the samples are worked over and all data are recorded on seasonal graphs for each pond. One of the plankton graphs shows the abundance of microcrustacean food organisms and often makes possible a prediction of starvation (figure 2). Another plankton graph shows the fluctuations in the algal population (figure 3). For ponds with a history of summerkills, the graph can be used to determine the best time for control of algae. The ammonia and carbon dioxide values obtained from the analysis of the water sample are useful as indicators of heavy decomposition that may have caused a summerkill.

The best indication of pond conditions is obtained by comparing the growth of the fish in each pond with the normal growth curve for walleyes in ponds. Average growth of 2.3 inches in 60 days indicates that the pond contains a normal walleye population numbering about 2,800. Faster growth indicates a smaller population and slower growth indicates a larger population (figures 4 and 5).

A few examples will illustrate some of the characteristic growth graphs that are obtained for Minnesota walleye ponds. The smooth line on each graph represents normal walleye growth. The line connecting X's shows the walleye growth in the pond for that season.

The graph of walleye growth for Big Stone Pond illustrates fish growth that is associated with an average fish population (figure 6). On the basis of this growth,

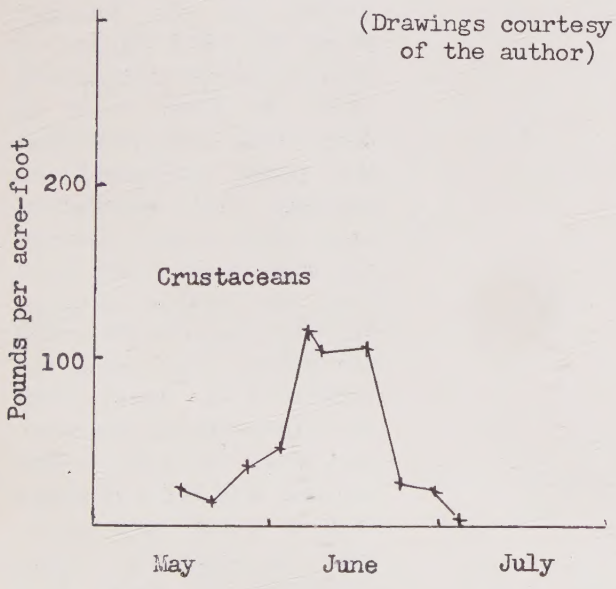

FIGURE 2.--Hinckley Pond, 1954: the abundance of crustaceans.

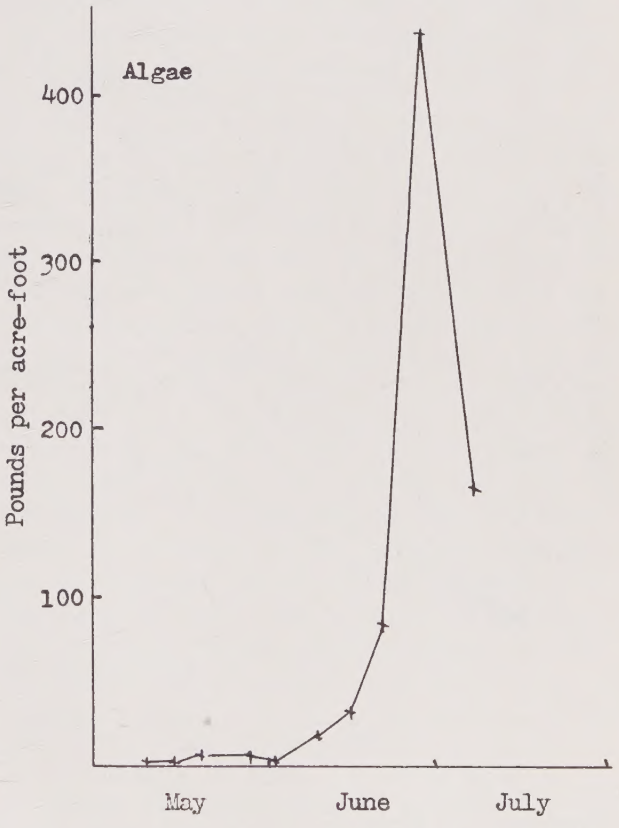

FIGURE 3.--Hinckley Pond, 1954: the abundance of algae.

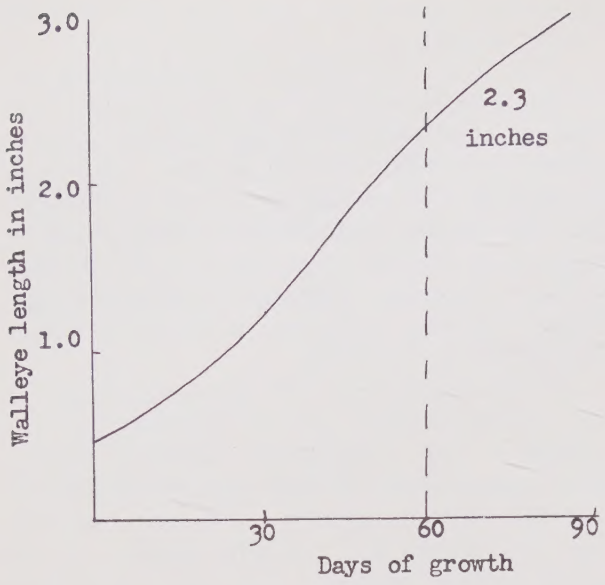

FIGURE 4.--Normal growth of walleyes in ponds.

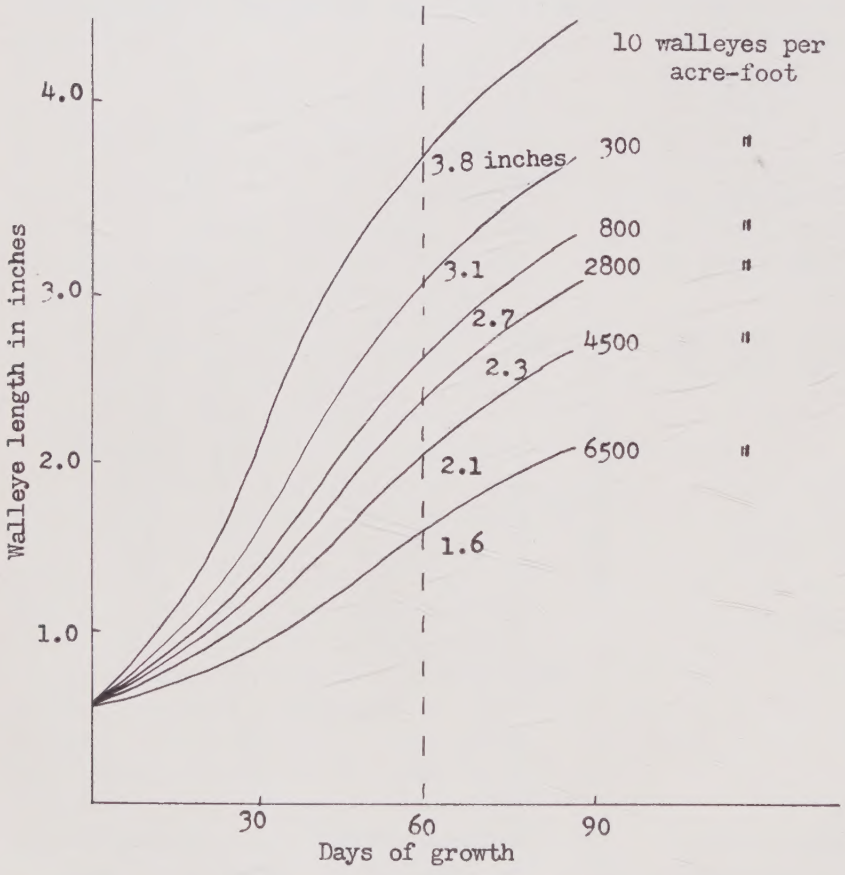

FIGURE 5.--Relationship between population density of walleyes in ponds and average length of fish.

the pond should produce about 2,800 fish per acre-foot. If the production is less, the loss of fish probably occurred shortly before the pond was harvested. If there had been a large loss at an earlier date, the change in the population would have produced a noticeable deflection in the growth curve.

The graph of walleye growth for Garrison Pond in 1953 illustrates the type of growth that can be expected when there is a heavy mortality at the time of fry stocking or shortly afterwards (figure 7). Plankton samples showed an ample supply of food at stocking time. Collections of aquatic insects at the same time showed a large population of predatory insects. In 1955 the predatory insects were killed 2 days before the fry were stocked and the pond produced a good crop of fish for the first time in 3 years.

The graph of walleye growth for Melrose Pond for 1955 illustrates the growth associated with a heavy population of fish (figure 8). A pond with this type of growth curve must be watched carefully for signs of starvation and cannibalism.

The graph of walleye growth for the Bemidji Pond for 1953 (figure 9) shows normal fish growth until the first week in July and indicates that the pond contained an average fish population until that time. During the rest of July the field man was unable to catch any fish for his biweekly samples. This condition indicated a heavy fish mortality during the second week in July. The harvest showed a population of 5 fish per acre-foot in August. The stomachs of those fish that were taken during July were empty, and the

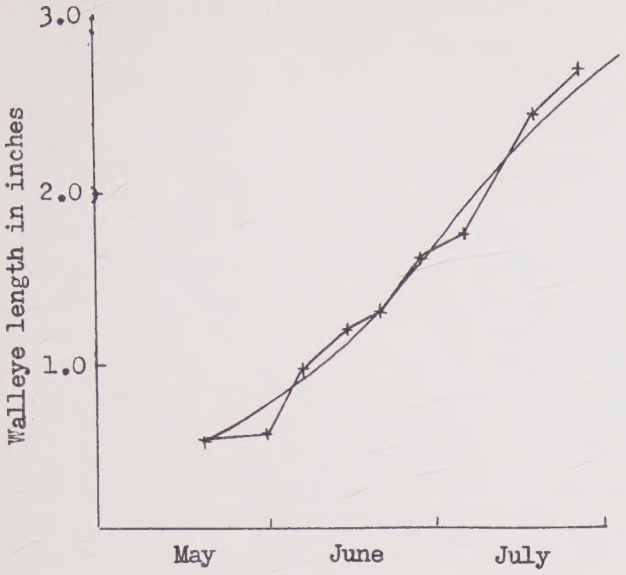

FIGURE 6.--Big Stone Pond, 1955: the growth of walleye fingerlings in a normal fish population.

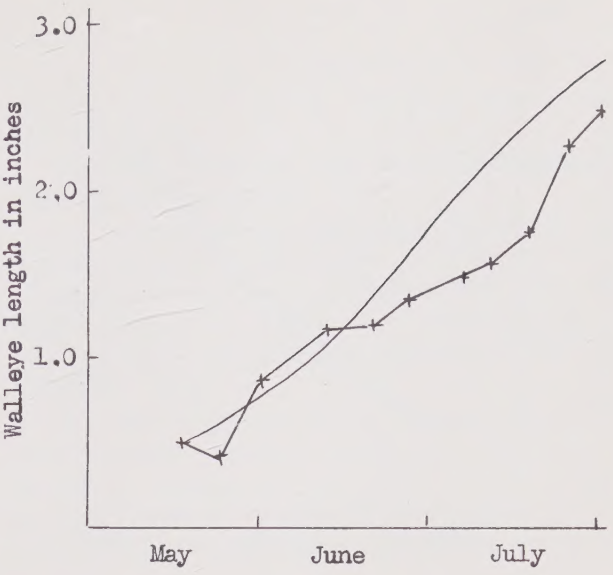

FIGURE 8.--Melrose Pond, 1955: the growth of walleye fingerlings in a large population.

zooplankton population was very low at the same time. These facts indicated that the fish starved to death. Consequently, the pond was watched closely for starvation during 1954. On June 30, a number of starving fish were washed into shore, a crew was brought in, and the fish were removed before a large loss had occurred. By this action 2,511 walleyes per acre-foot were obtained instead of the 5 per acre-foot obtained in 1953.

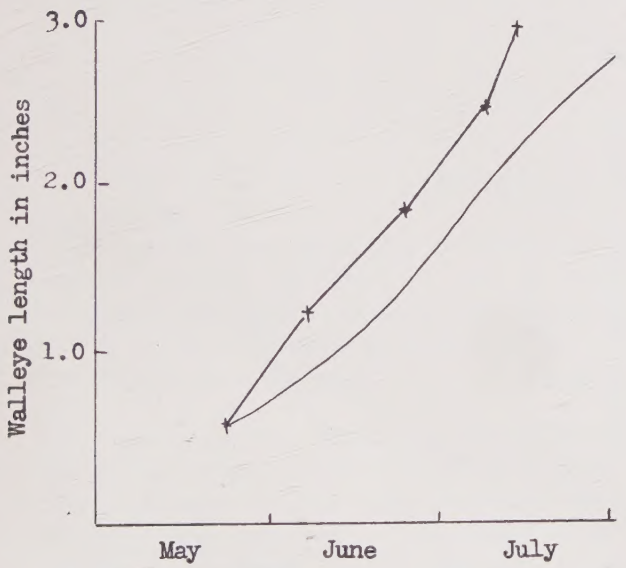

FIGURE 7.--Garrison Pond, 1953: the growth of walleye fingerlings in a pond that had heavy mortality when fry were stocked.

The graphs for Sedan and Winnie Ponds (figures 10 and 11) show two curves that are also associated with starvation and cannibalism. The difference in the shape of the curves is due to the severity of the starvation and cannibalism and to the resulting change in the walleye population. Sedan Pond apparently suffered a large loss of fish early in July, and the remaining fish grew at a faster rate. The walleyes in Winnie Pond apparently existed on starvation rations for a while and showed no growth. The shortage of food occurred when the fertility of the pond became tied up in an algal bloom to the exclusion of the zooplankton. The breakup of the algal bloom produced an oxygen depletion, and the whole fish population was lost.

Summary

From the standpoint of practical pond management, this system provided a method of evaluating pond conditions and determining when and how to remedy

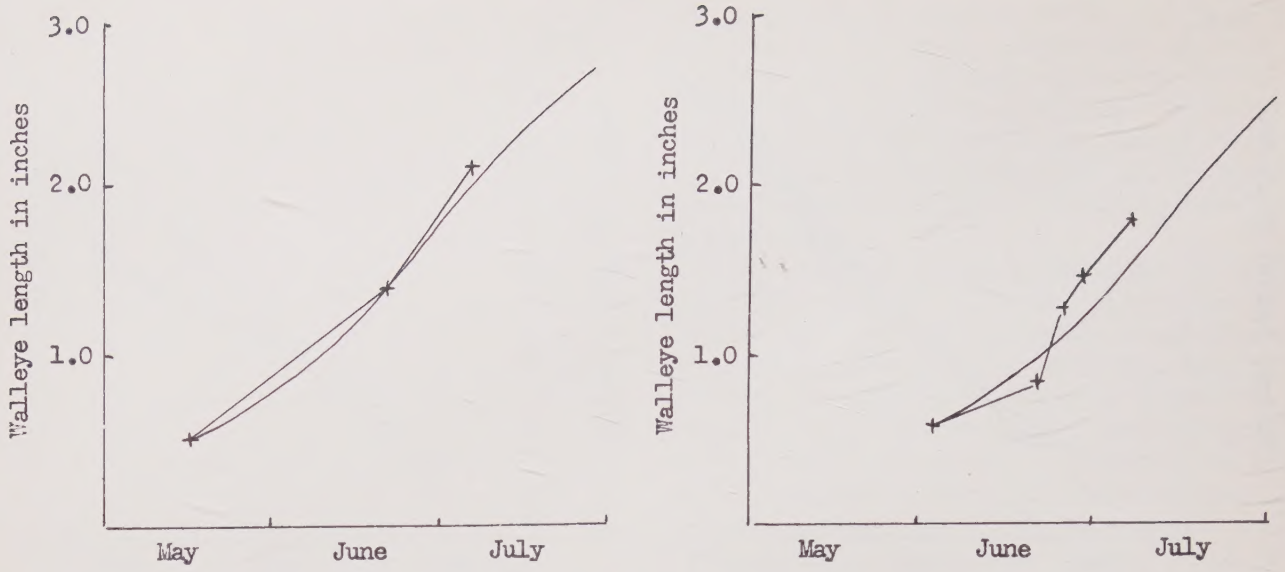

FIGURE 9.--Bemidji Pond. Walleye length in 60 days, about 2.7 inches. In 1953 (left): Number of fish per acre-foot, 5; July crustaceans, 11 pounds per acre-foot; July stomach contents, 0 percent full. In 1954 (right): Number of fish per acre-foot, 2,511; July crustaceans, 25.6 pounds per acre-foot; July stomach contents, 100 percent full; dying fish, 0 percent full.

adverse conditions. The system was used on drainable walleye ponds in Minnesota during 1954 and 1955 with satisfactory results. During 1954, when nearly all occurrences of loss from starvation and cannibalism were eliminated or greatly reduced, the fish production of the ponds (the total number of fish from 27 ponds) was increased by 127 percent. During 1955, when the losses from starvation and

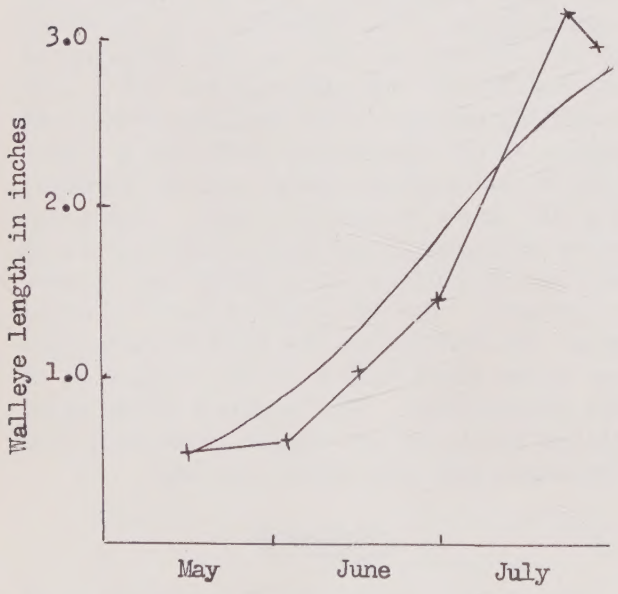

FIGURE 10.--Sedan Pond, 1953: growth of walleye fingerlings affected by starvation and cannibalism.

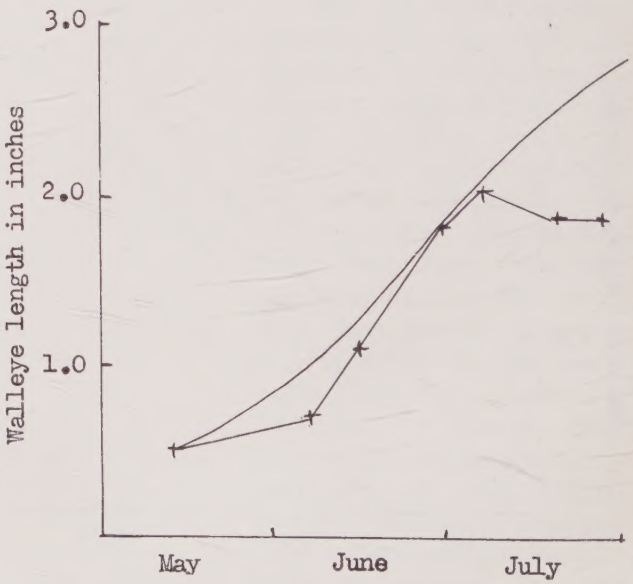

FIGURE 11.--Winnie Pond, 1953: growth of walleye fingerlings affected by starvation.

cannibalism were controlled, the losses from summerkill were nearly eliminated by controlling the algae with copper sulfate, and the losses from insect predation were eliminated by killing the insects on some ponds before fry stocking time--the fish production was increased another 30 percent. There is a possibility that, with the perfection of these controls, fish production from these ponds can be increased even more.

During the years 1953, 1954, and 1955, when the fish production increased 194 percent, the ponds were fertilized with organic fertilizers on the basis of soil fertility. The ponds with sand soils were also planted to rye in order to increase the amount of organic matter in the pond soil. If the sand soils can be improved so that each soil contains at least 4 percent of organic matter, the insect population of the soils should be increased enough to support a large fish population during the slump in the zooplankton population early in July. Then, the fish in the poorer ponds can be grown to a larger size than is possible at present.

During these 3 years the maximum poundage was obtained from each pond by cropping the fish over a period of a month or 6 weeks instead of removing all the fish at one time. The exceptions to this procedure were the ponds that showed signs of starvation and cannibalism and the ponds that had to be drained early for dry-fallowing.

All this adds up to a threefold system of pond management:

1. A method of watching the ponds in order to determine when a loss of fish is likely to occur--and then preventing it. When losses do occur, the pond manager can usually tell when it happened and the probable cause.

2. When the cause of losses has been determined, future losses can be eliminated by removing fish before a shortage of food occurs, controlling predatory insects, and preventing summerkill by algal control.

3. Maximum food production can be obtained by a combination of fertilization and dry-fallowing.

Literature Cited

Dobie, John.
1951. A method of measuring the natural food content of rearing ponds. Prog. Fish-Cult. 13 (3): 131-135.

DIETS FOR CHINOOK SALMON

From the feeding trials conducted with chinook salmon in 1954 at the Salmon-Cultural Laboratory (Entiat, Washington) of the U. S. Fish and Wildlife Service, it has been concluded that--

> ... meat-viscera diets with 10 percent meals were superior to 50 percent meal diets if both growth and mortality are used as the criteria. Variations of the meat components in 50 percent meal diets indicated that equal parts of hog liver and salmon viscera produced as much growth as did the Cortland combination of beef liver and hog spleen. During the cold water period the diets containing either salmon viscera as the sole raw product or hog liver and salmon viscera combined were inadequate. The substitution of seal meal for salmon offal meal in the Cortland No. 6 mixture resulted in as good or better gains. Greater amounts of distillers solubles substituted for salmon offal meal, however, apparently had a depressing effect on the growth rate.

--B. D. Combs, D. D. Palmer, J. H. Finucane, and R. E. Burrows: Tests of hatchery foods for salmon, 1953 and 1954. Spec. Sci. Rept.: Fish. 160. August 1955.

HISTOPATHOLOGY OF FISH
III. PEDUNCLE ("COLD-WATER") DISEASE

E. M. Wood and W. T. Yasutake
U. S. Fish and Wildlife Service
Cook, Washington

IN THEIR SYMPOSIUM PAPER ON INFECTIOUS DISEASES OF PACIFIC SALMON, Rucker, Earp, and Ordal (1954) reviewed a disease caused by Cytophaga psychrophila, a myxobacterium isolated by Borg.[1/] The disease is unique among fish bacterial infections, as the etiological agent is apparently most virulent at low water temperatures; i.e., 40° to 50° F. Infected fish often develop lesions anterior to the tail, and the condition is often referred to as "peduncle" disease. The disease is most serious in coho salmon (Oncorhynchus kisutch); but apparently it occurs to some extent in chinook salmon (O. tshawytscha), particularly when these are adjacent to infected lots of coho salmon (Rucker et al. 1954).

Methods and Materials

Late in June of 1955, Dr. R. R. Rucker collected specimens of coho and chinook salmon fingerlings which were undergoing a high mortality at the Quilcene (Washington) Station of the U. S. Fish and Wildlife Service. The water temperature was 46° F., and the fish exhibited typical gross symptoms of "cold-water" disease.

Examination of these specimens was made at the Fish and Wildlife Service's Salmon Nutrition Laboratory at Cook, Washington.

The samples were fixed in Bouin's solution for 24 hours and stored in 70 percent alcohol. The fish were small (maximum size, 2 inches), and longitudinal paraffin sections were made of each specimen. Hematoxylin and eosin, Giemsa, and Gram staining procedures were utilized.

Results and Discussions

The coho salmon were affected by an acute septicemic bacterial infection with certain distinguishing characteristics. The head, particularly the mouth, and the kidney were the most consistently affected areas. The causative agent was frequently found in the gills; and massive concentrations were observed in the heart, peritoneum, and spleen of various individuals.

The bacteria were morphologically similar to the myxobacteria, being long, slender Gram-negative rods. On the head, the epithelium was replaced in focal areas by great masses or swarms of bacteria which extended into the subcutaneous tissues and underlying muscle (figure 1). Such lesions were particularly prominent on the roof and floor of the mouth, the lower jaw, and the operculum. It might be possible to confuse this condition with the "red mouth" disease described by Wagner and Perkins (1952), as both conditions result grossly

1/Borg, A. F. Studies on myxobacteria associated with diseases in salmonid fishes. University of Washington, Ph.D. thesis, 162 pp. 1948.

(All the photomicrographs are of Giemsa-stained sections at magnification of 1350.)

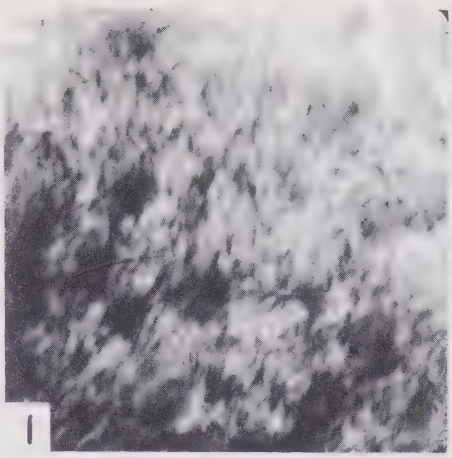

FIGURE 1.--A swarm of myxobacteria in the subcutaneous tissues beneath the epithelium. Note the scarcity of inflammatory cells.

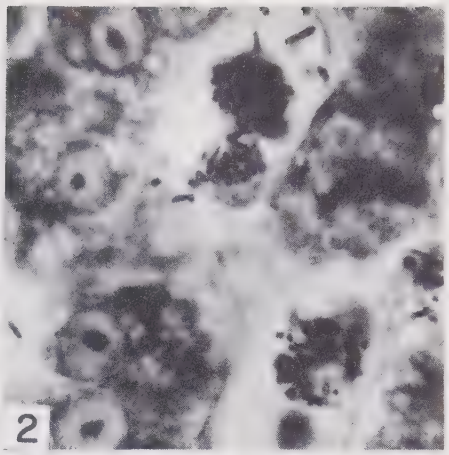

FIGURE 2.--Pseudomonads in liver tissue from red-mouth disease. Note the different morphology of the organism and the inflammatory cells which are engulfing the bacteria.

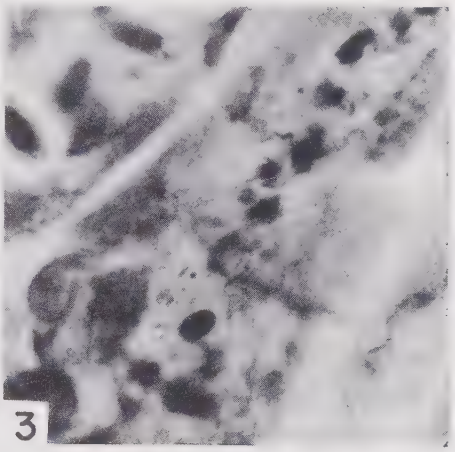

FIGURE 3.--In cold-water disease, the myxobacteria are found in the gill only in the central capillary of the platelet.

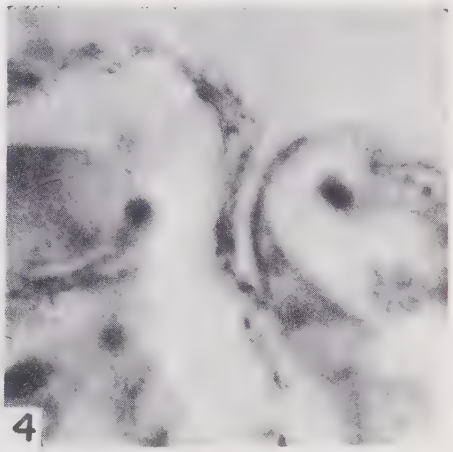

FIGURE 4.--In typical gill disease, the myxobacteria are found on the surface of or between the gill platelets.

in somewhat similar mouth lesions and both are associated with Gram-negative rod-shaped bacteria. Morphologically, however, the myxobacterium C. psychrophila is much longer and more slender than the pseudomonad involved in red-mouth disease (figure 2). In addition, we have observed in pseudomonad infections a very active inflammatory response which was characteristically absent in cold-water disease.

Marked concentrations of the organisms were found in areas of increased vascularity. In the gills, the small capillaries in the respiratory platelets were the primary site of the bacteria (figure 3). These organisms were not observed on the surface epithelium of the platelets or between them. That is a helpful distinction between this disease and other types of myxobacterial gill diseases where the organisms often tend to cluster on the outside of or between the respiratory platelets (figure 4).

The kidney lesions were unusually consistent and specific. The organisms had an apparent marked affinity for the renal glomeruli, where they were observed in large numbers. The glomerular capillaries were often solid masses of myxobacteria (figure 5). The tubules leading from affected glomeruli were in various stages of necrosis and degeneration, indicating that renal function was markedly

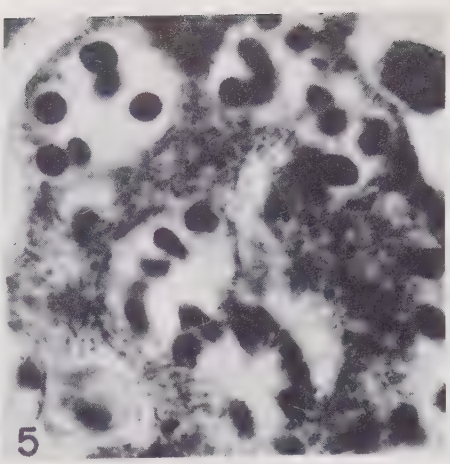

FIGURE 5.--The myxobacteria show marked affinity for the capillaries of the kidney glomeruli.

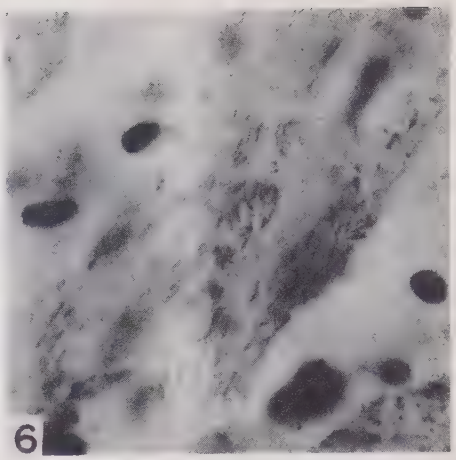

FIGURE 6.--The organism attacking the muscle fibers of the heart.

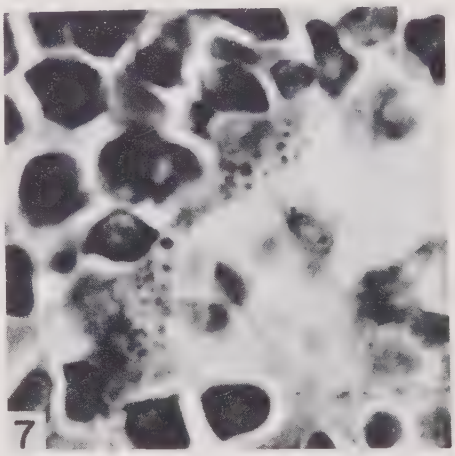

FIGURE 7.--The cytoplasmic inclusionlike particles in the kidney of a chinook fingerling.

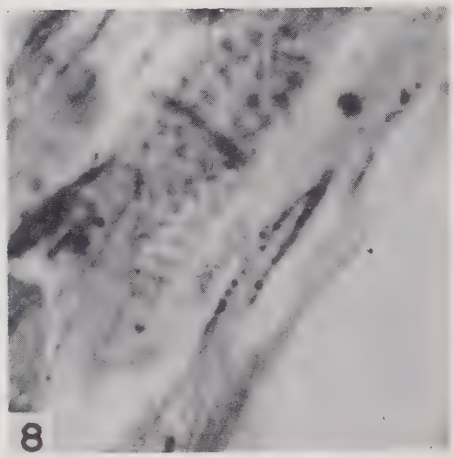

FIGURE 8.--The inclusion-like bodies in a muscle fiber.

affected by the disease. In contrast to kidney disease, which most actively affects the hematopoietic tissue (Wood and Yasutake 1956), peduncle disease is more selectively damaging to the renal elements of the kidney. In addition, kidney disease is characteristically a chronic infection; peduncle disease, an acute infection.

In the heart, the organism attacked the individual muscle fibers, causing slight inflammation and necrosis (figure 6). This lesion was probably the specific cause of death in many fish.

Although the organisms tend to concentrate in certain tissues, the disease is a true septicemia. In different specimens, large concentrations of organisms were seen in the spleen, muscle wall of the intestine, air bladder, peritoneum, and liver, and--to a lesser degree--in the pancreas.

The histopathology of the disease in coho and chinook salmon confirms the bacteriological observations already reported (Rucker et al. 1954). In coho salmon the disease is septicemic, but this does not appear to be true in chinook salmon. Those workers were able to isolate the bacteria from only the gills of chinook salmon. Histologically, we also observed the organisms in the gills only, with the exception of a chinook fingerling that had a heavy mantle on the caudal peduncle. This mantle consisted of a massive concentration of bacteria extending from the dorsal surface to the spinal cord.

Of considerable interest, however, were additional lesions in the chinook fingerlings which were not associated with bacterial organisms. Small hemorrhages were numerous in the dorsal and ventral muscles. The kidneys were the site of frequent inflammation, necrosis, and tubular degeneration. The spleen and

pancreas were also affected by inflammatory changes. In most of these lesions, particularly in the kidneys and muscles, inclusionlike bodies were observed within the cytoplasm of affected cells (figures 7 and 8).

There was a very marked similarity between the lesions observed in both species of fish. In coho salmon, the lesions were usually filled with great masses of myxobacteria. In chinook salmon, such bacteria were never observed in the internal organs although the lesions were present. The presence of inclusionlike particles in the cells of these lesions strongly suggests that peduncle disease in chinook salmon is associated with an additional etiological agent, possibly a virus. This may also be true with coho salmon, where the great masses of bacteria may obscure a supplementary agent. The large swarms of bacteria which occur frequently in coho salmon without causing an inflammatory response also lead to this supposition. It is also possible, however, that these intracellular particles represent a pleomorphic form of the rod-shaped myxobacteria.

Summary

1. Histologically, the myxobacterial infection known as cold-water or peduncle disease is an acute septicemic infection in coho salmon.

2. The Gram-negative organism shows a strong affinity for the head, particularly the mouth, and for the renal elements of the kidney.

3. In chinook salmon, the organisms are found in the gills, rarely in the dorsal muscles, but not in the internal organs. The presence of cytoplasmic inclusion-like particles in lesions of internal organs and muscles suggests the implication of a supplementary etiologic agent.

4. The histological differences between this myxobacterial infection and red-mouth disease, gill disease, and kidney disease are described.

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A camera under construction will withstand pressures at 1,000 fathoms. It will be used to survey the bottom over great areas of the banks, to study scallop beds, to investigate invertebrate fauna upon which many groundfish depend, and to study other problems of undersea biology related to commercial fishes.

That the Federal Aid funds are filling a real need is demonstrated by the fact that in fiscal year 1955 only $19,495--less than half of 1 percent of total obligations for the year, and representing small amounts unused in the States of Ohio, Rhode Island, Utah, Virginia, and Wyoming, and in the Commonwealth of Puerto Rico--reverted to the Fish and Wildlife Service for use in its sport fish research program.

A NEW MECHANICALLY ADJUSTABLE MULTI-SIZE FISH-GRADER

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Wizard Falls Trout Hatchery
Camp Sherman, Oregon

BECAUSE THE BENEFITS to be derived from the accurate grading of hatchery-reared trout are great, considerable effort has been expended in the development of an efficient grader. The accompanying photographs show a new design for grading fish into five size groups -- for grading them automatically and with a minimum of labor.

The three-way grader described by Morton in 1953 was an improvement over conventional graders, but it left much to be desired. That grader was made mostly of wood, had too many small moving parts, and would, over a period of time, require considerable maintenance. Also, operation of it required two men.

The new design has eliminated all springs, hinges, wedges, and wings; and it is made entirely from aluminum and plexiglas, with sheet-rubber troughs that are used to carry the various sizes of fish to their respective live-cars. Being made of aluminum and plexiglas, the machine requires no painting and, given reasonably good care, should last indefinitely with a minimum of maintenance.

There were several reasons for the selection of plexiglas (acrylic clear) for use in constructing the grader. The most important advantage of the plastic is its light weight, one-half that of aluminum of equal thickness. Lifting the grader in and out of deep ponds and carrying it over slippery pond bottoms make lightness necessary. Other advantages of plexiglas are that it is wholly compatible with animal tissue, it is virtually unaffected by water and chemicals, and it is not subject to corrosion or oxidation. The extreme smoothness of the plexiglas when wet is also an important advantage.

Though the design of the grader is simple, the fabrication of the plexiglas parts is difficult for the layman. Assistance in building the first experimental model of the grader (figure 1) was rendered by the Bettcher Plastics Company of Portland, Oregon. The grader shown in figure 1 was made entirely from the writer's crude drawings. During the construction it became obvious that additional reinforcement was necessary, and it was decided to use angle aluminum along the sides and continuous threaded aluminum rods for support of the vertical plastic separators. It had been planned originally to use plexiglas tube for spacers between the separators, but this proved unsuccessful. The use of the continuous threaded rod, with nuts and washers on each side of each separator, solved the problem nicely. Thus each separator can be regulated so that it is rigidly suspended and centered between the two lower and larger plexiglas tubes, a necessity for efficient operation.

The main objective in the grader design was to have a continuous, adjustable, tapering slot. This was secured by having the lower set of large tubes rigidly spaced and fused into one unit supported by two 1/2-inch aluminum rods running through the lower plastic sheets which support the large tubes. The rods, in turn, are

supported by hangers that extend to the adjusting wing nuts. The wing nuts tip the large tubes away from the stationary smaller tubes above, creating a tapering slot 4 feet long. The amount of taper is dependent upon the size of fish to be graded. The upper and vertical plastic sheets (1/4 inch thick), to which the small tubes (1/2 inch) are fused, not only help to form the tapering slot, but also serve as separators by keeping the fish parallel with the slot and thus preventing the fish from piling up in one groove.

The overhead spray system is an important addition to the new design. This system permits the elimination of one man from the operation and--because of the angle of the jet streams as they strike the large tubes in each slot--lubricates the surfaces, helping to keep the fish moving along and supplying water to the rubber troughs that are attached underneath to carry the fish to individual live-cars.

The aluminum rods that support the rubber troughs are 12 inches apart. The slope of each trough is alternated so that two sizes of fish come out on one side and two sizes on the other, thereby permitting use of a live-car 24 inches wide and about 36 inches long for each size group. The largest fish (group 1) go over the end of the grader. (See figure 2.) The next largest fish (group 2) slip through the slots in the last 12 inches of the grader and come into the first box to the left of group 1. Fish one size smaller (group 3) go through the slots of the preceding 12 inches of the grader and enter the first box to the right of group 1. Fish two sizes smaller (group 4) enter the second box to the left of group 1. The smallest fish (group 5) go through the first 12 inches of the grader, appearing in the box second to the right of group 1. Two extra live-cars are on hand so that they can be substituted quickly for loaded boxes. Numbers are painted on small wood blocks with hooks, making quick changes possible. It is important to have all live-cars numbered to show the group size, for they can easily become mixed when moved away from the grader. It is possible to have different rubber troughs so that only three or four size groups, instead of five, will be collected.

The adjustment of the grader is important and must be made with precision. This adjustment can be accomplished with machinist's calipers. One fish from the group to be graded is selected to represent group 1, or fish of largest size. The calipers are fitted snugly to the fish, and then the grader is adjusted by turning the two lower wing nuts until the space between the large and small tubes is equal to the caliper setting at the lower end of the grader. From experience with other graders, it was determined that a grading slot of less than 1/4 inch was unnecessary. Consequently, the new design starts with a 1/4-inch opening, but it cannot be made smaller. For grading small fingerlings, it usually is not necessary to make any adjustment, as the 1/4-inch opening will automatically take care of them once the grader is set to take out the largest size. The constant taper of the slot will automatically let the intervening sizes slip through. The foregoing, generally speaking, will take care of fish running 60 per pound and smaller. For grading larger fish, it usually will be necessary to adjust the upper end of the grader to permit larger fish to enter the group 5 size. From the fish that are to be graded, one is selected to represent the smallest size and its diameter is determined with the calipers. If the fish is larger than 1/4 inch, the upper part of the grader should be adjusted accordingly. If, after the grader has been set for the large size, the smallest opening is enlarged, then the setting for the largest size should be rechecked. A tipping action that occurs will slightly close the lower end of the grader when the upper end is dropped. Even though the movement is slight, it can make a difference in efficiency and should always be checked.

Once the grader has been set up in the pond and properly adjusted and all the fish have been corralled between crowders, the actual grading takes very little time. The apparatus will grade fish just about as fast as one man can pour them on the rubber apron at the head of the machine. A

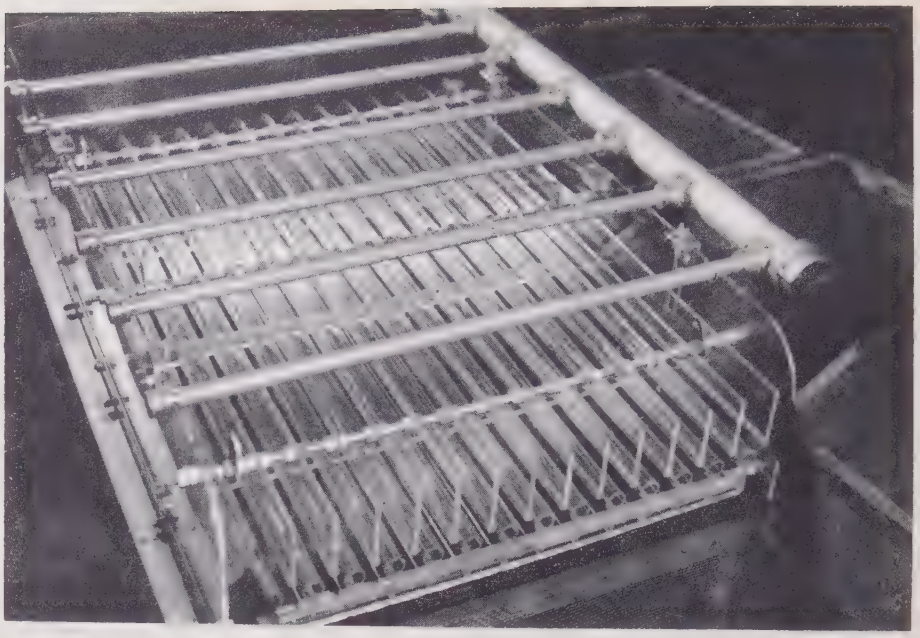

FIGURE 1.--First experimental five-size grader made from aluminum and plexiglas. Water-spray manifold is all aluminum pipe. The two lower wing nuts (one on each side) regulate for the largest sizes; the two upper wing nuts (one on each side) regulate for the smallest size.

(Photographs courtesy of the Oregon State Game Commission.)

FIGURE 2.--The same grader with live-cars: foreground, the box for the largest fish (group 1); left, boxes for groups 2 and 4; right, boxes for groups 3 and 5. The hose connects the grader and hatchery water supply.

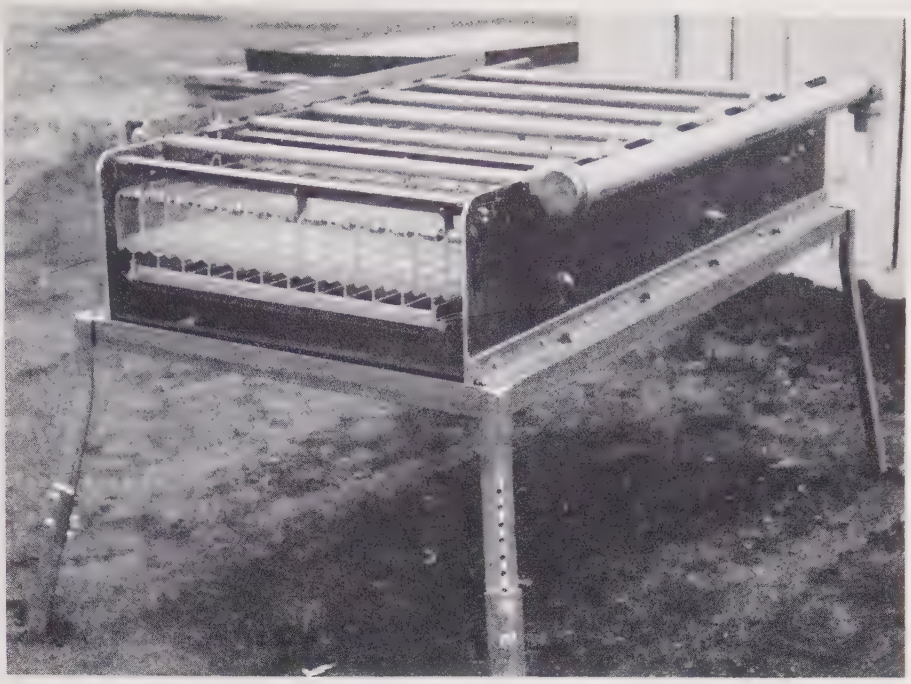

FIGURE 3.--An improved model of the Morton grader. The aluminum sides and angle aluminum provide more rigid support of plastic separators. Slope for this grader is regulated with the adjustable legs on the separate stand.

2-inch hose is connected either to the hatchery water supply or to a small pump. It is important that reasonably good pressure be applied to the water-spray system, as the jet streams help a great deal in keeping the fish on the move and well separated. Blueprints for the machine show only one jet of water to each slot, but experience has shown that it is better to have two jet holes drilled for each slot, and especially so for the first three cross pipes at the head of the grader. It has been learned also that no matter how straight the 1/8-inch holes for the water jets are drilled, they have a tendency to squirt the water to one side or the other and thus impair the efficiency of the device. Correction can be obtained by marking places for new holes while the spray system is in operation.

The slope of the grader can be regulated by the adjustable legs at its lower end. The smaller the fish, the more slope is required; but it should be borne in mind that the more nearly level the grader, the more efficient will be the grading process. It is surprising to see that the grader can be quite level and yet the fish will work their way along the tapering slots. In grading yearling fish, the grader is kept almost level. Occasionally a few of them will appear to be stuck; but if more fish are added, the slightest nudge from an oncoming fish will cause the stopped fish to move on down the grader. The tapering slot and the round tubes make it nearly impossible for fish to gill themselves. It has been observed that between species, and between various lots of the same species, there is much difference in the way they will grade. Fish that are full of pep, healthy, and in good condition require much less slope of the grader than do fish that are listless and in poor condition.

The following example shows the efficiency of the grader and the delicate adjustment that is necessary for grading small fingerlings. The fish graded were spring rainbow trout about 4 months old. An inventory made on October 1, 1955, showed 170,577; and the sample count on that day was 63.1 fish per pound. The fish were graded on October 11, 1955, with the following result:

Group	Pounds	Per pound	Numbers
1	474	38.0	18,012
2	496	49.0	24,304
3	777	63.0	48,951
4	575	80.0	46,000
5	331	113.0	37,403
	2,653	65.63	174,634

Surprisingly, there was an increase of only 3/16 inch in the taper of the slot from

the upper to the lower end of the grader, or an increase of less than 1/16 inch per running foot of the 4-foot grading slot. Only the lower end of the grader was adjusted for the grade. The fish were in eight circular ponds. Thirty-six man-hours were required to do the job, which comprised setting the grader up, moving it and all the other equipment--including scales, tubs, live-boxes, crowders, and dip nets--into eight separate ponds, and weighing and distributing the various size groups to their respective ponds (which were 100 to 200 feet from the grading operation). The time required for one man to put the fish through the graders was 2-1/2 hours. Had all the fish been in one pond, the time required to grade them would have been much less.

An experiment with a fast-growing strain of rainbow trout has demonstrated that this grader, by eliminating the danger of cannibalism and permitting the use of more conservative feeding rates, has saved within a year many times its cost.

Acknowledgments

The writer wishes to acknowledge the assistance of Mr. Donald M. Jacobson, of the Oregon State Game Commission's engineering staff. Mr. Jacobson made valuable suggestions for improving the grader.

Messrs. L. M. Mathisen, H. J. Rayner, E. W. Goff, H. R. Mangold, and Clark Walsh--all of the Oregon State Game Commission--contributed substantially in bringing this project to a successful conclusion.

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A PRACTICAL ICE-AUGER FOR THE FISHERY BIOLOGIST

To make an ice-auger large enough for many biological purposes, H. J. McKirdy, district fisheries biologist of the North Dakota Game and Fish Department, makes the following suggestion from his headquarters at Gladstone, North Dakota:

"Acquire an auger of the type used in coal mines for blasting purposes. These augers are 3 feet long and 2 inches in diameter.

"Heat the end of the auger in the coals of a blacksmith's forge; when the end is hot enough, pound it until it is about 3 inches wide. Split the flattened end in the center, making a cut approximately 1 inch deep. Re-heat the end; then bend the two points apart and twist to make a spiral shape. This should make the end of the bit 4 inches in diameter. Next temper the end of the bit and cool it slowly in water. (If the tip or end chips when used, it has not been tempered correctly and probably is too hard.) Now take a steel bolt (about 1/2 inch in diameter and about 1 inch long), heat it and make it square, taper it to a point, and weld it in the center of the bit. This will keep the auger from creeping on the ice.

"The auger is now ready to be attached to any type of starter motor."

(Illustrations courtesy of Mr. McKirdy)

SOME CYTOLOGICAL OBSERVATIONS ON FISH ERYTHROCYTES

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U. S. Fish and Wildlife Service
Cook, Washington

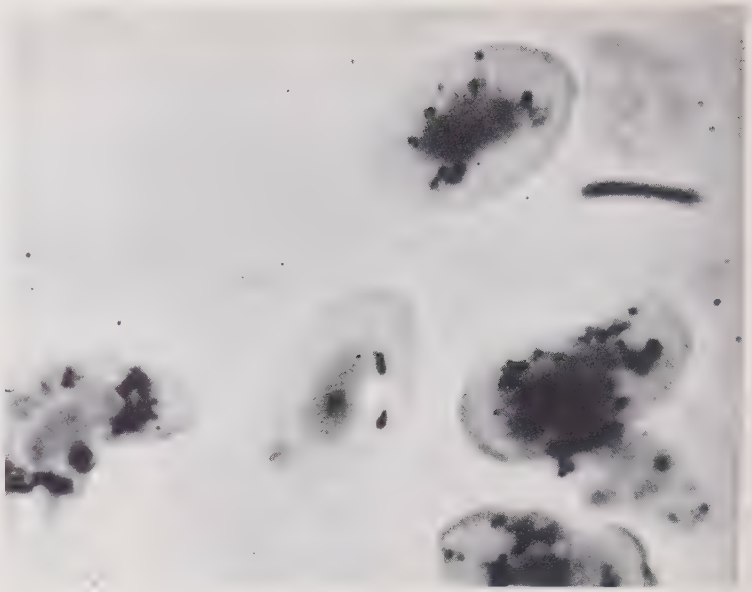
MANY PEOPLE are surprised when they learn that within the cells of almost every living thing there are minute rod-shaped or threadlike bodies which move like tiny worms or motile bacteria. The cytologist has known and studied these subcellular forms--which are called mitochondria--for many years. These studies have demonstrated that mitochondria have certain characteristics by which they may be distinguished from other cytoplasmic granules and from intracellular parasites. The most specific of these characteristics is the property of staining supravitally, i.e., in living cells, with very dilute solutions of Janus green B. Mitochondria also stain supravitally with dilute methylene blue. In contrast to bacteria, mitochondria are soluble in alcohol, ether, chloroform, and acetic acid, and therefore are destroyed by most of the common histological fixatives. They are also destroyed by heat fixation. For this reason, mitochondria are not seen in the usual sections or smears. However, they are readily observed in wet mounts, especially with phase microscopy, because they are more refractile than the surrounding cytoplasm.

One cell that does not contain mitochondria is the mammalian erythrocyte, or red blood cell. During the development of this cell, the nucleus, the cytoplasmic reticulum, and mitochondria all disappear. In certain anemias, however, immature red cells which still contain reticular material and, in some cases, mitochondria are shed into the circulatory system (Krumbhaar 1928). Therefore, in mammals, the presence in the blood stream of red cells which contain reticulum or mitochondria is of clinical significance as an indication of anemia.

In recent years there have been developed methods which allow the isolation of mitochondria in a very nearly unaltered state and quite free of contamination with other cellular elements. Biochemical studies of these isolated mitochondria have added greatly to our knowledge of the organization and regulation of important metabolic reactions occurring in the cell. For example, the mitochondria have been shown to be the sites of most of the energy yielding reactions in the cell. These considerations, along with the fact that mitochondria might be mistaken for intracellular parasites, have prompted the preparation of this brief report on some cytological observations made on fish erythrocytes.

The presence of mitochondria in the red cells of fish--cells which are normally nucleated--has been reported by Cowdry (1914), who observed them in goldfish, and by Shipley (1915), who did not name the species on which the observations were made. Fishery biologists may overlook these early references because they are not readily available and are not concerned primarily with fish. In a recent report, Catton (1951) did not mention mitochondria occurring in the red blood cells of mature brown trout (Salmo trutta), roach (Rutilus rutilus), and perch

(Perca fluviatilis). Since then, Watson, Guenther, and Royce, who used the phase microscope, have observed mitochondria in the erythrocytes of blueback salmon (Oncorhynchus nerka) fingerlings.[1/]



Photomicrograph of salmon erythrocytes showing vitally stained mitochondria. Some cells have been distorted by the pressure of the cover slip. Magnification, 1400X.

Material and Methods

The blood samples used for this study (conducted at the Fish and Wildlife Service's Salmon Nutrition Laboratory near Cook, Washington) were obtained by severing the caudal artery. A small drop of blood was placed on a slide which had previously been prepared by evaporating a thin film of alcoholic solution of the vital dye (1/500 solution of methylene blue, 1/500 solution of brilliant cresyl blue, or 1/10,000 solution of Janus green B) on its surface. A glass cover slip was immediately placed over the drop of blood so that it spread in a thin film. Observations were begun immediately.

Experimental Work

We have observed that the red cells of both fingerling and adult fall chinook salmon (O. tshawytscha), adult blueback salmon (O. nerka), and adult rainbow trout (Salmo gairdneri) contain mitochondria and reticular material in addition to nuclei. The mitochondria stain supravitally with dilute Janus green B, methylene blue, or brilliant cresyl blue. The latter dyes are less selective than Janus green B, and soon the nuclei stain as well as the mitochondria. After more prolonged treatment with these dyes, the reticular material also stains, thereby obscuring the mitochondria. At the same time, the nuclei swell and begin to decolorize. The amount of reticular material in a given red cell varies and is probably correlated with its relative age. However, no cells observed have been completely devoid of mitochondria and reticular material. The photomicrograph shows salmon erythrocytes in which the mitochondria have been vitally stained with methylene blue. The mitochondria of salmon erythrocytes are short, thin rods which, when stained, swell into the form of dumb-bells or spheres. They are in constant motion in the living cells and consequently are difficult to count and measure. Apparently, however, there are from 6 to 20 per cell, the average number being 14, and their size is approximately 1 to 2 microns by 0.3 micron. Fixation by heat, ethanol, or methanol destroys the original appearance of the mitochondria. The cytoplasm, after these fixation procedures, does contain granular material that probably is derived from the mitochondria. This material is very apparent in smears of fish blood stained with the usual Wright's stain.

[1/] Watson, M. E., R. W. Guenther, and R. D. Royce. Hematology of healthy and virus-diseased sockeye salmon (Oncorhynchus nerka). Unpublished. (Direct inquiries to Dr. R. R. Rucker of the U. S. Fish and Wildlife Service at the Fisheries Center, University of Washington, Seattle, Wash.)

There have been attempts to stain the mitochondria of fish erythrocytes with the iron hematoxylin or aniline-fuchsin-methyl green techniques after fixation in Regaud's or Helly's fixatives. These attempts have not been successful, apparently because of the similarity of the staining characteristics of the membranes and mitochondria of fish erythrocytes. This is substantiated by the observation that in sections of salmon kidney in which the epithelial cells of the tubules have been successfully stained for mitochondria, the erythrocytes present are so heavily stained that no cytoplasmic details can be seen in them.

From the results presented in this report, it appears that the mere presence of mitochondria or reticular material in fish erythrocytes, as demonstrated by vital staining, is not a good indicator of anemia. However, a comparative study of normal and anemic fish bloods, using both supravital and standard methods of staining blood, would probably reveal some useful characteristics.

The fish erythrocyte appears to be useful for studies in cellular physiology because of the importance of mitochondria in metabolism and because these cells can be obtained in fairly large numbers, relatively free of contamination by other cellular types. It should also be noted that, as a consequence of their level of intracellular organization, the erythrocytes of fish may be capable of supporting the growth of such intracellular parasites as viruses and rickettsiae.

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EYE AND BEHAVIOR DIFFERENCES

Biologists studying various species of fish in the South Pacific for the U. S. Fish and Wildlife Service suggest that anatomical differences in the eyes may be related to differences in behavior. From studies made of the eyes of the sardine, anchovy, Pacific mackerel, and the jack mackerel, it appears that differences in the anterior rectus (the muscle that rotates the eye forward) may conform to differences in activities.

The anterior muscle in the sardine is well developed and inserted at the center of the eyeball. In the anchovy, this muscle is also inserted at the center but is poorly developed. In the Pacific mackerel and jack mackerel, this muscle is split, the dorsal segment extending to the forward margin of the eye and the ventral being attached at the center. Related forms suggest that these differences are at the family level. Anterior insertions in these mackerels indicate that they train the eyes forward to use binocular vision in taking prey; central insertions in the sardine and anchovy indicate less specialization for particulate feeding. Poorer development in the anchovy may mean that it is exclusively a filter feeder, whereas the sardine resorts to particulate feeding at times.

BEAVER-TROUT RELATIONS IN NEW MEXICO

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WIDELY DIVERGENT VIEWS OF THE RELATIONSHIP BETWEEN TROUT AND BEAVER have been held by fishery workers in various sections of the country. That beaver will increase the water surface and volume in streams is unquestioned, and this fact alone has made the animal an important factor in trout management in the Southwest. The actual effect of this increase in terms of population size and quality, however, apparently is little understood. As the beaver can at times be somewhat of a nuisance, some gauge of their value to trout production is essential in order to determine the relative values in such situations.

During the summer of 1955, an investigation of the effect of beaver activity on trout habitat and populations was initiated by the New Mexico Department of Game and Fish. The study was designed to determine the effect of beaver activity on trout production (with respect to both numbers and size of trout) and, insofar as possible, to find the reasons for any such differences.

Procedure

The upper Red River was chosen for the study because of its being a typical New Mexico trout stream and because of its accessibility.

A short section of stream containing several beaver dams and the unchanged stream immediately below and above were chosen for the test section. Here the Red River flows at an elevation of approximately 9,500 feet through spruce, fir, and aspen forests. The stream is often bordered by alders and willow thickets.

Rubble forms the stream bottom except in the beaver ponds, where silt and detritus, several feet deep in places, have been deposited.

The flow of water is approximately 20 cubic feet per second at the upper end of the test section. Just below the beaver-dams area the south and west forks of the river join, and below this point the flow increases to approximately 50 cubic feet per second.

Six 50-yard sections were chosen randomly from the area involved. Three were from the part that contained active beaver workings, and three were outside this part. It was arbitrarily decided to choose one of the latter sections from above and two from below the beaver sections, as this was considered the best way to obtain comparable water in both groups of sections. Beaver sections will hereafter be designated as B, and non-beaver sections as NB.

The three non-beaver sections differed greatly in physical characteristics. Section I(NB) was below the forks and had a flow of approximately 50 cubic feet per second at a velocity of 3.2 feet per second. This section contained the remains of an old beaver dam that formed a 30- to 40-foot pool with a maximum depth of 4 feet. Unlike active beaver ponds, no still water was involved and, consequently, no silt or detritus was deposited on the bottom. Section II(NB) was also below the forks and was composed entirely of riffle area with very poor pool grade.

Section VI(NB) consisted of two channels flowing parallel at a distance of about 50 yards. Pools in this section were small but fairly abundant.

Two beaver sections contained two or more dams and ponds. Section III(B) was made up of two ponds of almost equal size. The dam of the lower pond was broken at one end, and a channel cut to gravel bottom through the pond. The maximum depth in the lower pond was approximately 4 feet; in the upper, 3 feet. Section IV(B) contained the largest single pond in the group as well as two smaller dams. The maximum depth in the large pond was 5 feet. The dam of this pond washed out during the period between inventories, and the pond was dry for an undetermined time. Section V(B) had one pond, in general more shallow than either of the other sections, with many stumps and fallen trees in the water.

Two censuses of the fish population of each section were made, one in June 1955 and the other in August 1955.

All collecting was done by electrofishing. A 115-volt alternating-current generator and paddle-type electrodes were employed during most of the work. Late in the study, the two-wire electrode system described by Holton and Sullivan (1954) was introduced and found to be much more satisfactory for the work involved. Normal operation of this type of equipment was possible in all sections except section IV(B), where the depth of the pond prohibited wading. During the first inventory electrofishing from a boat proved fairly satisfactory, but efficiency was so lacking during the second census that the pond was drained and an actual count of the fish was made. It should be noted that the discarded estimate was 60 fish for this section and the actual number was 79. As this latter figure included all fingerlings found in the section, and it was assumed that the estimates were uniformly low because of incomplete sampling below 3 inches, even this estimate is seen to be surprisingly accurate.

In each section test fish were introduced just prior to the census. These were marked by removal of a fin or portion thereof. The number of such fish used ranged from 5 to 18, depending upon the amount of water involved in the section; and all these fish were obtained from the stream in the immediate vicinity of the test sections. The test fish were measured, and the lengths were recorded to determine the comparative size range of recoveries. The efficiency of the census in each section was calculated from the recovery of these fish and ranged from 18 to 60 percent. No test fish that was used had a total length of less than approximately 3 inches, and no effort was made to evaluate the efficiency of sampling fish smaller than this. It has been demonstrated repeatedly that the efficiency of electrofishing varies with the size of the fish involved, and it has therefore been assumed throughout this paper that all estimates are slightly low for this reason.

At the time of each census, collections of bottom-dwelling invertebrates were made in one beaver and one non-beaver section. These samples were taken from sections II(NB) and IV(B) in June and from I(NB) and V(B) in August. Eckman-dredge samples were taken from beaver sections, and square-foot samples from non-beaver sections. All were converted to values per square foot for comparison.

Water Quality

Temperature was the only apparent variable from section to section. In June, surface waters warmed from 43° F. in section VI(NB) to 46° in section V(B). The latter temperature was maintained throughout all three beaver sections.

In August, water was 42° F. in section VI(NB) and warmed to 50° in the first beaver-dam section, V(B). Again the water maintained that temperature throughout the beaver sections.

Vertical temperature differences in the beaver ponds were very slight. In June, at a surface temperature of 46° F., the temperature was reduced only 1° in 5 feet of water in the deepest pond.

No oxygen deficiencies occurred and the pH remained approximately 8.0 in all sections.

TABLE 1.--Estimated number of trout in test sections

		Sections			Ave.	Sections			Ave.
		I (NB)	II(NB)	VI (NB)		III (B)	IV (B)	V (B)	
June	Best estimate	79	3	16	33	187	169	105	154
	95% fiducial limit-----	(33-288)	(1-5)	(6-48)		(90-440)	(77-390)	(53-209)	
Aug.	Best estimate	80	22	40	47	249	94	200	180
	95% fiducial limit-----	(36-246)	(9-65)	(11-182)		(65-359)	(84-123)	(68-590)	
Average----------		80	12	27	40	218	131	153	167

Fish Populations

The following four species of fish were found in the area: Cutthroat trout (Salmo clarki), brook trout (Salvelinus fontinalis), rainbow trout (Salmo gairdneri), and white suckers (Catostomus commersoni).

Of the four species, only two--the cutthroat and the brook trout--are common in the stream. Cutthroat trout are probably native to the stream, and their number has been supplemented from time to time by plants of hatchery fish, mostly fingerlings. The date of introduction of brook trout is unknown, but none have been planted since 1929. These two species composed 99 percent of the collections in beaver sections and 98 percent in the non-beaver sections. The two species occurred in almost equal numbers.

Rainbow trout are planted at lengths of as much as 8-1/2 inches, but these trout made up less than 1 percent of the population. Suckers occurred in only two beaver ponds and in each pond composed less than 1 percent of the catch.

The population estimates for each section are shown in table 1. The average population per section for beaver sections was 154 in June and 180 in August, as opposed to 33 in June and 47 in August for the non-beaver sections. A test shows this to be a significant difference at the 99 percent level.

In no instance was there a larger population of trout in a non-beaver section than in a beaver section. The difference was extreme at all times except during the August inventory of section IV(B). The low population found in the large pond at the second census is probably explained by the loss of water already described.

The most productive non-beaver section was section I(NB). This section had a much better pool grade than either of the other sections, and this difference was due to past beaver activity in the area. In spite of this one high-population section, the highest non-beaver estimate was only 32 percent of the highest beaver-section estimate.

Section III(B), which--considering the fact that part of section IV(B) was dry for a short period--had the largest area and greatest volume among the beaver sections, had consistently the largest fish population.

Size and Growth

The length frequencies of trout taken from the test sections during the June inventory are shown in figure 1. None of these fish exceeded 10 inches in length. Although in the August inventory a few trout of as much as 13 inches were taken, these made up a very small part of the population.

Trout that were taken from beaver ponds averaged slightly larger than trout from non-beaver sections. The peak of the length-frequency curve for the beaver sections was 6 inches, whereas the peak for non-beaver sections was 5 inches.

Although this stretch of stream was accessible and was heavily fished during

the investigation, the large numbers of fish found and the narrow range of sizes indicate the presence of an overpopulation of trout, as judged on the basis of maximum production of desirable fish.

Approximately an inch of growth in the beaver ponds during the June-August period is indicated by the length frequencies shown in figure 2, in which the frequency peak moves from 5 inches in June to 6 inches in August. Though the number of fish involved from the non-beaver sections is small, no such shift is evident.

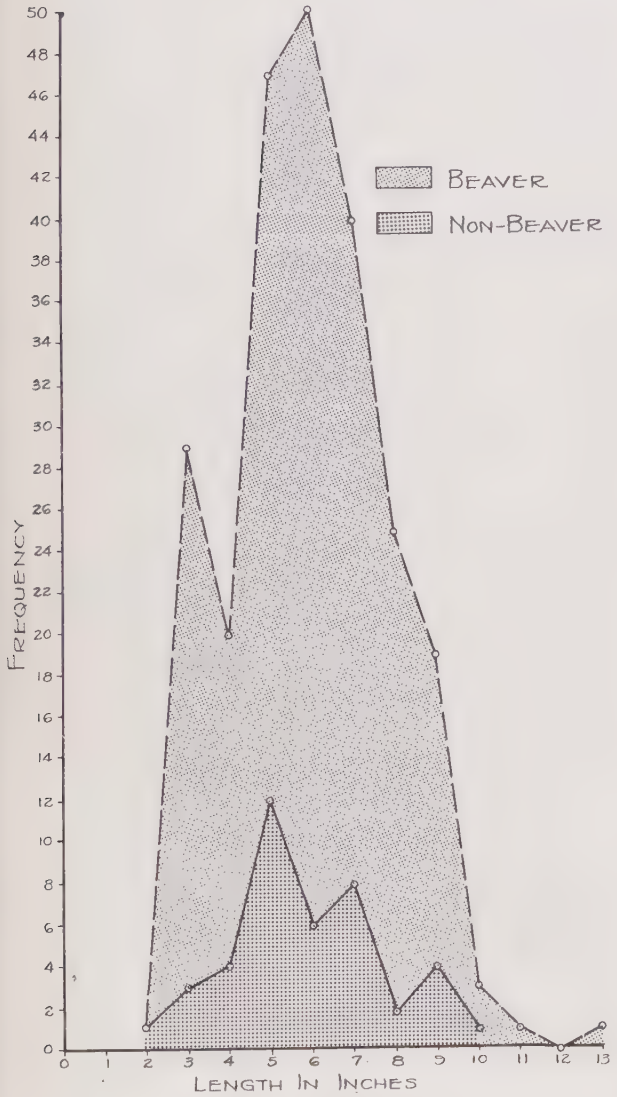

FIGURE 1.--Length frequencies of trout (Salmo clarki, S. gairdneri, and Salvelinus fontinalis) taken in test sections during the August inventory.

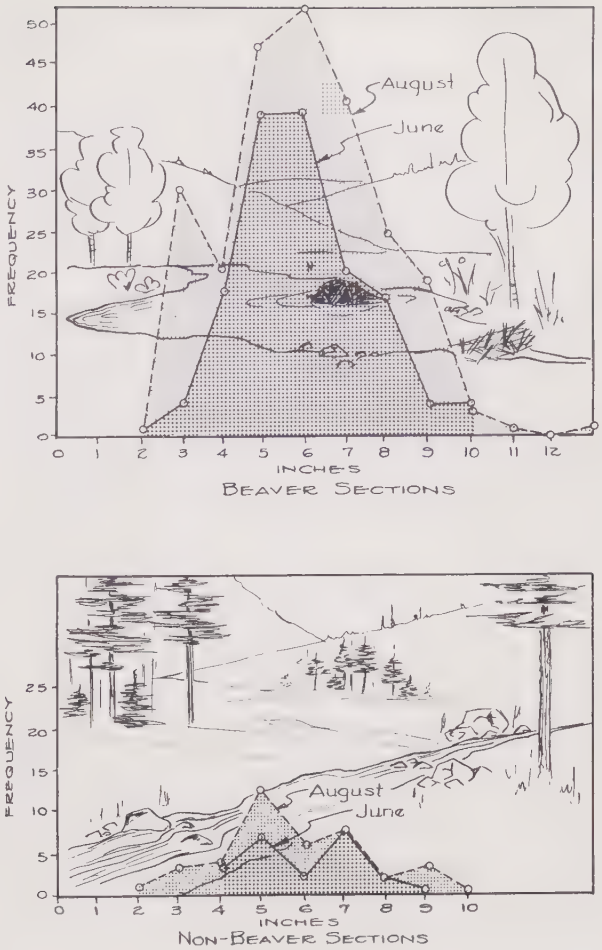

FIGURE 2.--Length frequencies of trout from beaver and non-beaver sections at both June and August inventories.

(Drawings courtesy of the author)

Trout Food

The results of bottom sampling are shown in table 2. A highly significant difference between the two sets of data exists in spite of the small number of samples taken. The 5 samples from beaver dams averaged 61 invertebrates per square foot and 2.9 cubic centimeters per sample. Samples from the non-beaver sections, on the other hand, averaged 16.8 organisms and only 0.5 cubic centimeter.

TABLE 2.--Summary of bottom-food samples from beaver and non-beaver sections

	Sections			
	Beaver (5 samples) Average		Non-Beaver (5 samples) Average	
	No.	Vol. (cc.)	No.	Vol. (cc.)
Hirudinea	----	----	0.6	-----
Gastropoda	10.4	-----	----	-----
Plecoptera	.4	-----	----	-----
Ephemeroptera	1.8	-----	11.0	-----
Trichoptera	6.7	-----	.8	-----
Lepidoptera	----	-----	.2	-----
Coleoptera	4.0	-----	.6	-----
Chironomidae	4.0	-----	----	-----
Other Diptera	33.7	-----	3.6	-----
Total	61.0	2.9	16.8	0.5

Discussion and Conclusions

All the data from the investigation point to increased trout production in beaver ponds. The fact that the ponds produced a significantly greater number of trout per linear stream area, coupled with the fact that growth was slightly better in the ponds, indicates a much greater volume of production in these areas than in undisturbed stream areas. It is also significant that the non-beaver section which produced almost 60 percent more trout than either of the other such sections contained the remains of past beaver activity.

Several factors may be wholly or partly responsible for this increased production. The increased water volume and--probably more important--the increased bottom area are undoubtedly of importance, as witnessed by the greater production in the larger section III(B). Two other changes in conditions, however, seem important. The increase in water temperature in the beaver ponds probably increases the level of production to some extent and, at the same time, increases the length of the growing season in the ponds beyond that of the stream. Possibly influenced by this increase in temperature, as well as by the change in bottom material, is the greater bottom-food production of the ponds.

The argument that beaver activity hinders movement of trout to suitable spawning areas--though theoretically possible--certainly was not valid in the area studied. It is known that brook trout have sustained themselves since 1929, and that cutthroat fry and fingerlings that could not possibly have been planted were abundant.

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... By New Zealand standards United States interest in angling seems extraordinary, as a high percentage of the public is attracted to angling despite the small size of trout, congested angling conditions, and inferior fish species. The fishing conditions which reasonably satisfy very many United States citizens would not satisfy the average New Zealander, who would have no interest in trout of the sizes most usually taken there and who for years has shown scant interest in much better perch fishing in this country than that available and highly popular in parts of the United States.--D. F. Hobbs, "Farm fish ponds in New Zealand," The New Zealand Journal of Agriculture, December 1954.

When plastic bags of better quality are available, fish will probably be mailed from one part of the country to another in a bag containing water and oxygen.

LIGNASAN FOR BACTERIAL GILL DISEASE

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BACTERIAL GILL DISEASE plagues salmon and trout in many hatcheries: some infections are sporadic, but others are continual. An inexpensive, easily applied, stable, safe chemical would be highly advantageous for treatment.

The use of Roccal as a 1-hour treatment for bacterial gill disease (Fish 1947) was developed at the Leavenworth (Washington) Station of the Fish and Wildlife Service in 1942 and was quite successful. Since then, Roccal has been used extensively; but because of variability in composition, its efficacy is not consistent (Rucker et al. 1949). The objection to the variability of Roccal was overcome by using another compound, pyridylmercuric acetate, which was suggested by Van Horn and Katz (1946) as having some therapeutic value. Pyridylmercuric acetate was tested experimentally at the Leavenworth Station and was found to be very effective for bacterial gill disease. This compound had highly differential toxicities for bacteria and fish but was quite expensive (Rucker 1948, Burrows and Palmer 1949, Snieszko 1949). Another objection to pyridylmercuric acetate was its toxicity to rainbow trout--not to other species of trout or to salmon--at the concentration necessary to control the bacteria (Seaman 1950, Rodgers et al. 1951, Bryant 1951, Foster and Olson 1951).

Experimental Work

In 1948 Katz published a list of compounds which were used in the paper industry and might be considered for fish therapy. In 1950 the fish toxicities of several of these compounds were determined for chinook salmon fingerlings (Oncorhynchus tshawytscha) at the Entiat (Washington) Station of the Fish and Wildlife Service; and in 1953 the bactericidal activity was determined at the State Fisheries Hatchery, Issaquah, Washington, according to the methods described by Rucker (1948). The fish were 2-inch, 3-month-old chinook salmon fingerlings in an early stage of bacterial gill disease. The water temperature was 56° F. Here Lignasan at a concentration of 1:500,000 controlled bacterial gill disease experimentally. Because of the finding in this work, Lignasan was used, although to a limited extent, in a number of other State hatcheries in 1954. Lignasan was found to be nontoxic, at the recommended concentration, for salmon; but it was found to be toxic to rainbow trout (Salmo gairdneri) fingerlings about 1 month old and 1 inch in length.

Lignasan was tested extensively in 1955 at the Leavenworth Station, where trial of the preparation to prevent the development of bacterial gill disease was under the supervision of Alfred C. Gastineau, assisted by Roy N. Hammerlin. The fish used were about 4 million sockeye salmon (O. nerka) fingerlings reared from early spring through the fall of the year. These salmon normally developed bacterial gill disease within a month at this station if no prophylaxis was administered. The water, which was low in mineral content, had temperatures ranging from 42° to 58° F. A number of ponds were treated

biweekly for 1 hour with a 1:500,000 concentration of pyridylmercuric acetate, which had been the standard practice for a number of years; this was considered a known control. Lignasan was tested at two concentrations, at 1:500,000 and at 1:250,000, for 1 hour; it was administered both as a liquid and as a powder at weekly and biweekly intervals. Two ponds received no treatment in order to demonstrate that the disease was always present and also to have infected fish for use in testing Lignasan as a therapeutic. The mortalities in the ponds that received prophylactic treatments were insignificant, indicating that Lignasan prevented the development of bacterial gill disease even when used every other week at a concentration of 1:500,000 for 1 hour.

The opportunity to use Lignasan to treat an active infection was afforded when the fish in the two untreated control ponds developed bacterial gill disease. One pond was treated with a 1:250,000 concentration for 1 hour at 53° F., and this caused a high loss of 7 percent. The other pond was treated with a 1:500,000 concentration for 1 hour, and this resulted in an insignificant increase in mortality. It is well known that treating a group of diseased fish causes a higher loss than treating a healthy group. That is one reason for the use of prophylactic treatments at stations plagued by endemic diseases. Even pyridylmercuric acetate, which is considered excellent for bacterial gill disease, kills more fish than desired when it is used as a therapeutic in an advanced stage of an epidemic.

Mortalities associated with Lignasan therapy occurred a few hours after treatment. It is advisable, therefore, to test the toxicity of Lignasan under the prevailing conditions of the individual hatchery; that is, for water, temperature, and the species of fish to be treated.

A group of sockeye salmon fingerlings was treated 1 hour weekly with 1:250,000 Lignasan from April 1 to mid-June, 1955, at the Leavenworth Station. The water temperature ranged from 44° to 46° F. The mortality was insignificant, which indicated no cumulative toxicity.

Lignasan was used successfully, at a concentration of 1:500,000 for 1 hour, to control bacterial gill disease in 2- to 6-inch (3- to 15-month-old) rainbow trout at the Winthrop (Washington) Station of the Fish and Wildlife Service. The water had a relatively high mineral content, and its temperature varied from 50° to 55° F. at different times when fish were treated. At this station pyridylmercuric acetate had been tried without success on rainbow trout of various sizes.

The use of Lignasan for the control of protozoan parasites has not been successful. It was tried on 1- to 2-inch rainbow trout at 48° F. at a private trout farm. The Lignasan was not toxic at 1:500,000, but it did not remove a stalked ciliate that normally responds to treatment with pyridylmercuric acetate or acetic acid. At the Cook (Washington) Station of the Fish and Wildlife Service, Lignasan was tested by Harlan E. Johnson as a control for a Trichodina infection on 3- to 4-inch chinook salmon at 46° to 48° F. Here both pyridylmercuric acetate and formalin were effective in removing the parasite, but Lignasan had no effect on it.

Discussion

Lignasan is a powder and contains 6.25 percent ethyl mercury phosphate and 93.75 percent inert material. At the Leavenworth Station a therapeutic that can be broadcast over the pond water is desired, and therefore the extra inert material has an advantage in affording better distribution. When Lignasan was used, quantities were weighed into containers which were used to scatter the powder over the pond water, or a concentrated solution was made, measured, and disseminated with a sprinkling can. The water level in a pond to be treated was drawn down below the level desired for the treatment. The Lignasan was then added to the pond while the inflow was bringing the pond water up to the treatment level. This procedure caused a mixing action in the pond and prevented the formation of hyperconcentrations of the disinfectant. The water was turned off after the Lignasan had been

added, and the fish were held in the water for 1 hour for the treatment; then the drain was opened, water was turned into the pond, and some of the water containing the Lignasan was drawn out before the drain was closed.

It is suggested that the draining of the pond be started before the conclusion of the 1-hour treatment period, and that the drainage be continued for a little while after the water inflow has been resumed. This procedure rapidly reduces the quantity of disinfectant remaining in the pond, so that the fish are exposed to the disinfectant for a minimum of time after the 1-hour treatment period is concluded.

The advantage of Lignasan over Roccal for treating bacterial gill disease is based on economy and consistency of composition. The advantage of Lignasan over pyridylmercuric acetate is a matter of economy. It is believed that if Lignasan, a product of E. I. du Pont de Nemours and Company of Wilmington, Delaware, is used at the Leavenworth Station next year as a prophylactic for bacterial gill disease, the saving will exceed $1,000.

As a result of these experiments, it is indicated that Lignasan may be substituted for pyridylmercuric acetate or Roccal for the control of bacterial gill disease. As a prophylactic, Lignasan is effective at a 1:500,000 concentration for a 1-hour exposure period administered at biweekly intervals. As a therapeutic, Lignasan is similarly effective.

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USE OF CMU TO CONTROL *NAJAS*

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SEVERAL ROOTED AQUATIC PLANTS have caused the appearance of serious weed problems in warm-water hatcheries in Tennessee. This report concerns the control of Najas through the use of CMU--3 - (p - chlorophenyl) - 1, 1 - dimethylurea--at the Springfield Hatchery, Springfield, Tennessee.[1/] At this hatchery, largemouth bass and bluegills are propagated for release in small ponds and lakes. The main source of water is a spring that has a methyl orange alkalinity of 144 p. p. m., a total hardness of 194, and a pH of 8. 5. Bass are propagated in the spring, and bluegills are raised in the same ponds during the summer. Extensive growths of Najas have interfered with hatchery operations in the following respects: (1) Commercial inorganic fertilizer is utilized to some extent by the higher aquatic plants rather than by desirable phytoplankton; (2) during the draining of ponds, large numbers of small fish get enmeshed in plants, making necessary extra labor to rake out the small fish; (3) numbers of small fish are lost when weedy ponds are drained; and (4) ponds cannot be drained at the exact time when bass are the correct size.

Methods

Experimental work with this herbicide was conducted on one pond in 1954 and on four ponds in 1955. In 1954, general observations were made; whereas in 1955, records were kept of water color (caused by growth of phytoplankton), temperature, amount of weed growth on bottom, and fish production. Three ponds were used as controls for all factors except fish production. Fish production figures were compared with those of the past 4 years. All ponds were fertilized regularly to maintain a growth of plankton in the water.

A grey, wettable powder, CMU was prepared for application by mixing dry with a commercial inorganic fertilizer. The mixture of CMU and fertilizer was applied to the surface of the water in two ponds and directly to the bottom of three ponds before they were filled with water (table 1). For this work, 80 percent CMU was applied at rates of (approximately) 7, 10, 15, and 20 pounds per surface acre.

Effect of CMU on Najas and Phytoplankton

CMU kills plant growth through the root system. On dry land, one application lasts about 3 years because it does not leach out rapidly below the depth of penetration of the root system. Periodically plants will start to grow on the treated soil but will die after the roots penetrate the deeper soil. In water, leaching is more rapid and one application will not last so long.

Pond 7 at the hatchery was treated in March 1954, and no vegetation appeared until late in May 1955. This vegetation disappeared as soon as the roots penetrated deep enough into the soil (about 3 inches) to contact the chemical. In August 1955, the pond had been dry since June and only shallow-rooted terrestrial grasses were growing.

[1/] CMU was supplied by E. I. Dupont De Nemours & Company.

TABLE 1.--Applications of 80 percent CMU in ponds at Springfield Hatchery, Springfield, Tennessee

Pond No.	Acreage	Date of application	C.M.U. applied (pounds)	Rate of application: pounds per surface acre	Rate of application: p.p.m. of water (approximate)	Where applied
1	2.002	March 16, 1955	14	6.99	0.1	On water surface
3	.880	--do.---------	9	10.23	1.0	On bottom
5	.903	--do.---------	18	19.93	2.0	Do.
7	.498	March 15, 1954	10	20.08	2.0	On water surface
8	.613	March 16, 1955	9	19.68	1.5	On bottom

When the ponds that had been treated in March 1955 were drained during the last weeks in May, none showed any good growth of aquatic plants. None of these ponds were refilled, because the hatchery required repairs. It is not possible to make general conclusions on the length of time that one application persists.

From the results, it appears that about 15 pounds of 80 percent CMU per acre should be applied. Pond 11, which received 7 pounds per acre, showed some plant growth when the pond was drained May 26, 1955.

The influence of CMU on the growth of phytoplankton was negligible. The density of phytoplankton was determined by immersing a white metal plate (4 inches square) in the water and reading, to the nearest inch, the depth at which the plate disappeared (table 2). All ponds were fertilized regularly with 12-5-5. Fertilizer was applied when the metal plate could be seen at a depth greater than 24 inches. There was no indication that more fertilizer was necessary to develop a bloom in treated ponds than in untreated ponds (table 2). Good growths of phytoplankton were found on all ponds treated with CMU except pond 7--which cannot be explained.

Effect of CMU on Largemouth Bass Production

The number of largemouth bass produced in 1955 showed significant increase over any of the previous 4 years (table 3). In 1955, all the ponds except pond 7 were treated with CMU. The control ponds were used to hold brood stock and to raise fathead minnows; therefore, data on the

TABLE 2.--Amount of fertilizer applied per month per acre to Springfield Hatchery ponds from March 16 to June 1, 1955, and the depth at which a 4-inch-square metal plate was obscured by plankton growth

	Ponds treated with CMU					Control ponds		
	1	3	5	7	8	2	4	6
Average daily depth (inches) at which plate disappeared---	23	24	22	Clear[1/]	20	22	20	20
Amount (pounds) of fertilizer applied per month per surface acre-----	250	230	300	636	730	280	420	276

[1/] For unexplained reasons, no growth of phytoplankton could be developed on this pond.

comparable production of largemouth bass in the same year could not be obtained. Over the past 5 years, approximately the same numbers of ponds have been in bass production. The principal reason for the increase in bass production was that all ponds without weed growth could be drawn down completely within 48 hours. In the previous years, about 7 days had been required to drain each pond. During that 7-day period, an extra man was required to rake the small fish from the weeds and many small bass were lost in the process. Also, because of labor required, only one pond could be drained at once. Because bass spawn at about the same time and grow at about the same rate in all ponds, a large percentage of the total production was lost through cannibalism as a result of the delay in harvest.

The total production by weight was not increased (table 3).

The hatchery superintendent estimated that more than 30 man-days, at the rate of $7 per day, were saved annually by the use of this chemical.

No fish mortality attributable to applications of CMU was observed in these ponds.

TABLE 3.--Largemouth bass production at Springfield Hatchery

Fiscal year	Number	Weight in pounds
1949-50	41,371	668.30
1950-51	43,353	676.20
1951-52	75,816	599.75
1952-53	47,491	460.20
1953-54	85,583	583.25
1954-55	203,762	603.00

Conclusions and Recommendations

From other areas it has been reported that large trees around ponds were killed when CMU was applied to the water. At the Springfield Hatchery, no terrestrial vegetation around any of the ponds was killed.

CMU is an expensive herbicide, and more experimental work will be necessary before the chemical can be used economically on a larger scale. The present study indicates that it will cost $45 per year per acre to control Najas.

As one application appears to be sufficient for an entire year of control, CMU is not considered too expensive to use. Bass production by numbers can be increased significantly, and the fish can be made available to pond owners at an earlier date. At this time, the weather is cooler and transportation is a lesser problem. Labor is saved, and the ponds can be prepared for bluegill production at an earlier date.

The hatchery program of the Tennessee Game and Fish Commission will include regular use of this herbicide unless a superior product can be found.

YELLOWFIN TUNA IN COLD AND WARM WATER

From the Honolulu headquarters of the Pacific Oceanic Fishery Investigations of the U. S. Fish and Wildlife Service comes the suggestion that variations in the abundance and distribution of equatorial yellowfin tuna may be related to the changes in ocean environment. Analysis of 1950-54 longline survey results has indicated that, along each longitude, relatively cold water was associated with poor fishing for tuna and warm water with good fishing.

Presumably the cold water is newly enriched by upwelling and has not had sufficient time to develop a nekton population that will serve as food for tuna. The warmer water, on the other hand, has "matured" insofar as the presence of tuna forage is concerned and apparently contains adequate amounts of forage.

THE SUCCESS OF A SEINE IN THE SAMPLING OF A LARGEMOUTH BASS POPULATION

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WHEN AN INVESTIGATOR is confronted with a fishery problem on a lake, the usual approach is to initiate some form of test netting. Associated with the selection of gear and the time of test netting will be the perennial question, "Will the fish sample be adequate and representative?" Unfortunately, there is seldom an opportunity to validate the selected method.

An unusual opportunity to check one common method was provided in the seining required to produce a "mark and recapture" estimate of the largemouth bass population in 396-acre Brown's Lake, Wisconsin. By keeping complete data on each of the 13 seine hauls required for the estimate, results from individual hauls could be compared with each other and with the final estimated population.

The nature of a successful seining operation suggests that it could have great potential as a sampling method. The seine used for this work was 2,000 feet long, capable of fishing depths of 15 feet. Half of this net had a mesh size of 3 inches, and the other half a mesh size of 2 inches (stretch measure). Practical operation of a "survey" seine in Wisconsin consists of mooring one end to shore, paying out the web in the form of a semicircle, and then pulling from one end. In this manner a large surface area of water is literally fenced in. Under ideal circumstances, one would expect to obtain a large and representative sample of fish and perhaps some measure of density.

Seining Problems and Fish Behavior

The seining was done in the fall, as this is a period when the fish are usually well distributed and neither impelled by spawning urges nor confined by excessive heat to cooler waters. However, during this period a large crop of rooted submergent vegetation was still standing, which caused difficulties in netting. As expected, the net tended to roll in the vegetation and to dig into the soft bottoms, which raised the web off the bottom and pulled the cork line below the surface for short periods. These difficulties were alleviated to some extent by adding pans and sticks to the lead line to avoid mudding and rolling. Also, from time to time snags caused damage to the web and pulled the cork line below the surface. However, despite these mechanical difficulties, all hauls took a large number of fish because of the reaction of the fish to the net.

The behavior of the fish was observed from a boat tied to the cork line. From this vantage point the fish could be seen moving at an unhurried pace well ahead of the webbing. In practice, the crew would usually cease operations for dinner when the enclosed area had been reduced to about 1 acre in size, and upon return the largemouth bass could be seen either stationary or slowly swimming about. Only when confined to a much smaller area (perhaps one-tenth of an acre), did they become excited and attempt to escape either by jumping or by charging the web.

Seldom were any gilled fish encountered. When withdrawn to a small area, the cork line of the net is placed over the gunwales of boats and--until the fish are impounded for handling--men are stationed at intervals to prevent escape over the corks. The consistent capture of 89 to 544 largemouth bass per haul led to a more thorough evaluation of seining results.

Representative Sampling

Assuming that largemouth bass are successfully netted where present, there arises a question about how representative the sampling is. For purposes of this study, there was a definite effort to sample a different location in each haul (figure 1) and 232 acres of water were covered.

A comparison of the length frequencies of the fish captured in each of the 13 seine hauls indicates considerable variation in the size distribution from one location to another within the lake basin (table 1, figure 2). For example, in the first haul fish 6 to 7 inches long predominated, in the second haul fish 11 to 13 inches long were dominant, and in the fourth haul fish 8 to 9 inches long were most abundant. If fish of different sizes had been randomly distributed, all hauls should have taken 11- to 13-inch fish in greater abundance because they were dominant in the angling and in the combined netting data (Mraz and Threinen, in press).

Further evidence of uneven distribution of various size groups was found by comparing the mean length of all fish captured in each haul. The range in mean length was from 8.6 to 11.47 inches, with the median at 10.04 inches. In some hauls large fish were missing altogether. Six of the thirteen hauls had no fish longer than 16 inches, a length at which a fish is usually 7 or more years old.

Density

By enclosing a known area with a seine, it should be possible to obtain a measure of fish-population density. The density of 29 individuals and 33 pounds per acre (Mraz and Threinen, in press) taken from

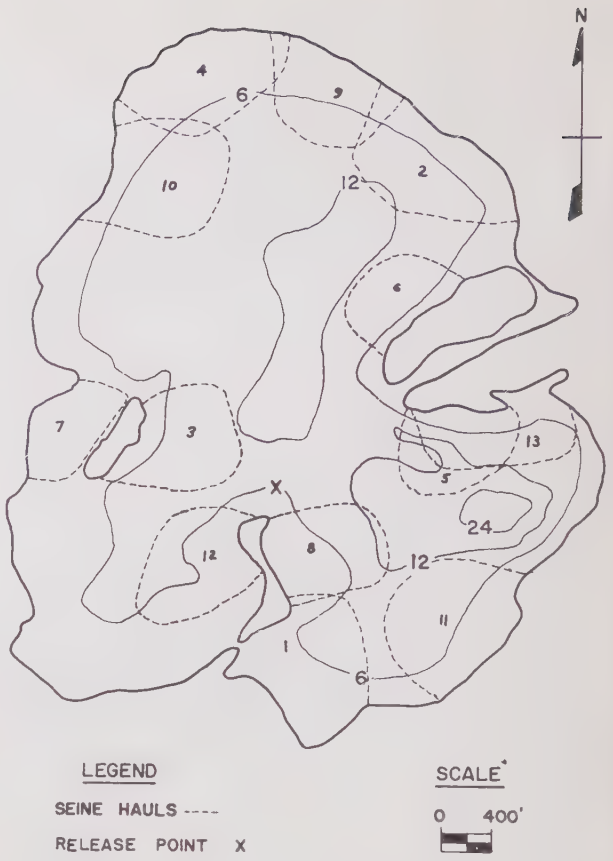


FIGURE 1.--Brown's Lake, Wisconsin.

(Illustrations courtesy of the author)

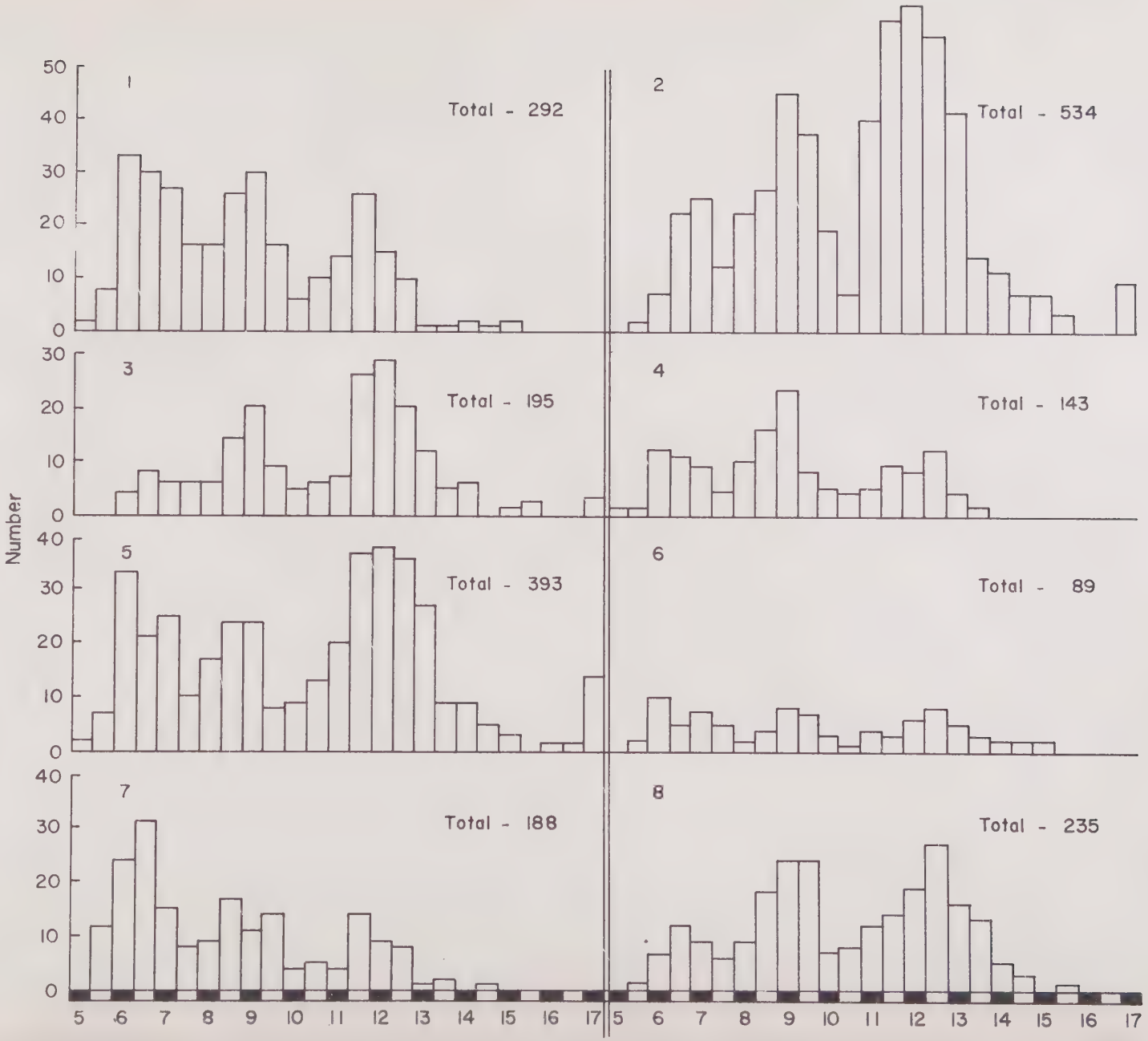
the population estimate can be used as a reference. Such a density amounts to an estimate for the fish population of the entire lake.

Each seine haul yielded a density of individual fish captured within the range of 9.9 to 25.6 fish per acre (table 2). The median for the 13 seine hauls was 13.6, and the mean for the total area covered was 16.3. As the average density for the entire basin was 29 individuals, it is evident that any single seine haul took between 34 and 88 percent of the average; thus, most hauls would have taken about half of the fish enclosed. The variation among hauls is no doubt caused by the uneven distribution of the fish around the basin and unequal netting success.

More variability was found in the weight density, primarily because of great variation in size of individuals in each haul.

TABLE 1.--Length frequency of largemouth bass in each of 13 different seine hauls from Brown's Lake, Wisconsin

Length	Haul number-- 1	2	3	4	5	6	7	8	9	10	11	12	13	Total
5.0 - 5.4	2	---	---	1	2	---	---	---	---	---	---	---	---	5
5.5 - 5.9	8	2	---	1	7	2	11	1	9	5	12	---	4	62
6.0 - 6.4	33	7	4	12	33	10	24	7	20	15	23	15	21	224
6.5 - 6.9	30	22	8	11	21	5	31	12	31	23	21	28	31	274
7.0 - 7.4	27	25	6	9	25	7	15	9	22	24	27	19	21	236
7.5 - 7.9	16	12	6	4	10	5	8	6	19	14	15	17	9	141
8.0 - 8.4	16	22	6	10	17	2	9	9	13	15	15	6	8	148
8.5 - 8.9	26	27	14	16	24	4	17	18	34	13	26	11	18	248
9.0 - 9.4	30	45	20	23	24	8	11	24	39	19	17	12	26	298
9.5 - 9.9	16	37	9	8	8	7	14	24	29	25	18	19	12	226
10.0 - 10.4	6	19	5	5	9	3	4	7	14	15	4	9	12	112
10.5 - 10.9	10	7	6	4	13	1	5	8	17	6	8	7	10	102
11.0 - 11.4	14	40	7	5	20	4	4	12	24	3	16	12	23	184
11.5 - 11.9	26	59	26	9	37	3	14	14	44	7	36	20	60	355
12.0 - 12.4	15	62	29	8	38	6	9	19	32	10	38	23	69	358
12.5 - 12.9	10	56	20	12	36	8	8	27	22	15	27	15	49	305
13.0 - 13.4	1	41	12	4	27	5	1	16	17	7	10	10	32	183
13.5 - 13.9	1	14	5	1	9	3	2	13	10	6	9	9	26	108
14.0 - 14.4	2	11	6	---	9	2	---	5	7	2	7	3	16	70
14.5 - 14.9	1	7	---	---	5	2	1	3	4	1	3	---	16	43
15.0 - 15.4	2	7	1	---	3	2	---	---	2	---	---	3	6	26
15.5 - 15.9	---	3	2	---	---	---	---	1	1	1	1	1	4	14
16.0 - 16.4	---	---	---	---	1	---	---	---	2	---	1	---	4	8
16.5 - 16.9	---	---	---	---	1	---	---	---	---	---	---	---	4	5
17.0 - 17.4	---	1	---	---	3	---	---	---	---	---	---	---	1	5
17.5 - 17.9	---	1	---	---	2	---	---	---	---	---	---	---	4	7
18.0 - 18.4	---	2	---	---	3	---	---	---	1	---	---	---	2	8
18.5 - 18.9	---	---	1	---	2	---	---	---	1	---	1	1	2	8
19.0 - 19.4	---	1	1	---	1	---	---	---	1	---	---	1	3	8
19.5 - 19.9	---	2	---	---	2	---	---	---	---	---	1	---	7	12
20.0 - 20.4	---	1	---	---	1	---	---	---	---	---	---	1	2	5
20.5 - 20.9	---	1	1	---	---	---	---	---	1	---	---	---	1	4
21.0 - 21.4	---	---	---	---	---	---	---	---	---	---	---	---	2	2
21.5 - 21.9	---	---	---	---	---	---	---	---	---	---	---	1	---	1
22.0 - 22.4	---	---	---	---	---	---	---	---	---	---	---	---	---	---
22.5 - 22.9	---	---	---	---	---	---	---	---	---	---	---	1	---	1
23.0 -	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total----	292	534	195	143	393	89	188	235	416	226	336	244	505	3,796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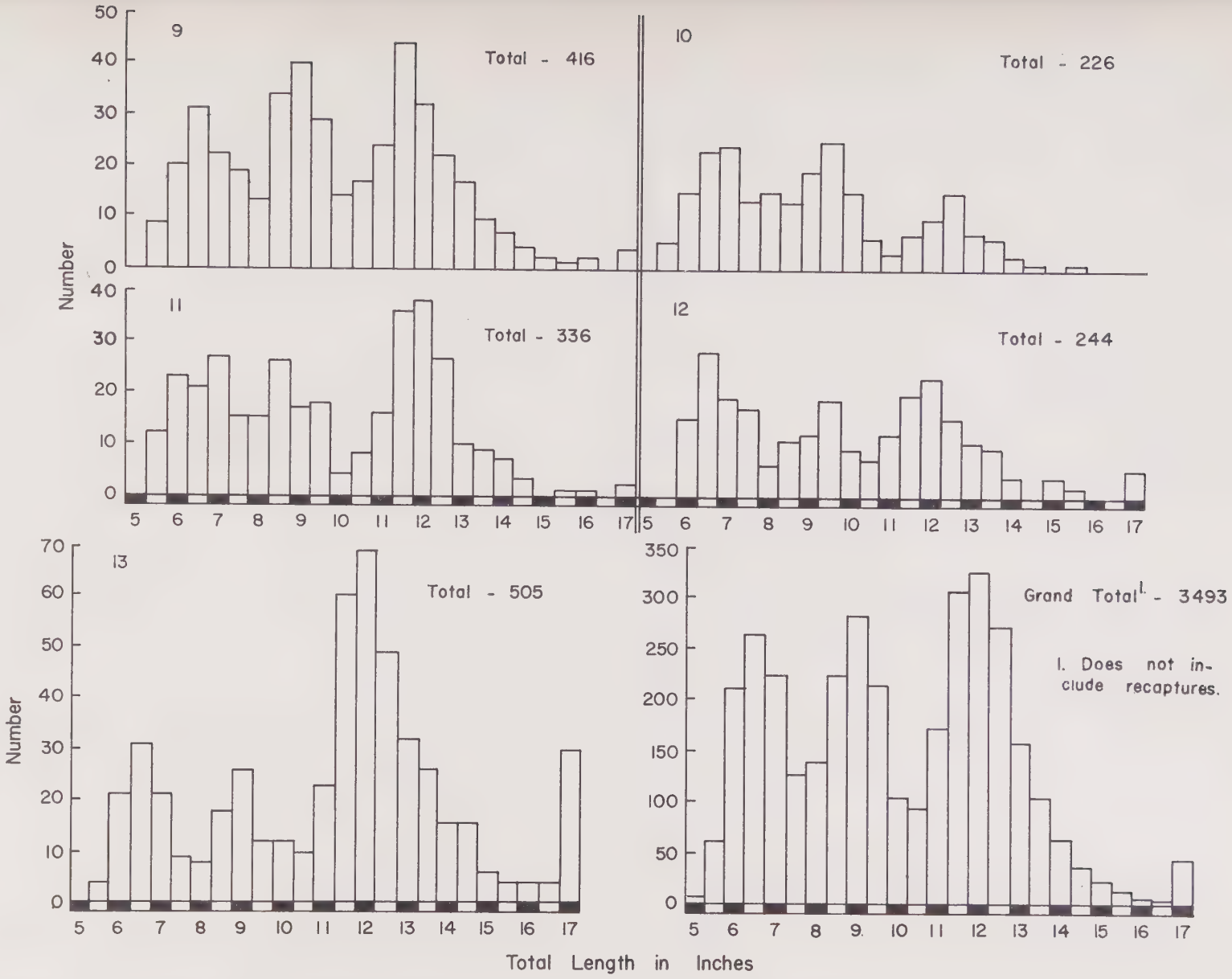

FIGURE 2.--Comparison of size range of largemouth bass from 13 seine hauls in Brown's Lake, Wis.

TABLE 2.--Density of largemouth bass encountered in seining Brown's Lake, Wisconsin

Haul number	Circumference of area seined (feet)	Estimated area seined (acres)	Total catch of largemouth bass	Number of largemouth bass per acre	Pounds per acre
1	3,980	28.9	292	10.1	3.84
2	3,805	26.4	544	20.6	14.61
3	2,835	14.6	195	13.4	9.23
4	2,760	13.3	143	10.7	4.48
5	2,805	14.6	374	25.6	17.81
6	2,220	9.0	89	9.9	4.94
7	2,835	14.6	188	12.9	3.57
8	3,545	23.0	235	10.2	5.73
9	3,195	18.0	416	23.1	11.23
10	2,785	14.3	226	15.8	6.56
11	2,785	14.3	336	23.4	10.55
12	3,175	18.3	248	13.6	7.46
13	3,535	22.8	492	21.6	15.14
Total and Mean-------		232.1	3,778	16.3	9.08

Weight density ranged from 11 to 54 percent of the mean of 33 pounds per acre computed from the population estimate. The median was only 7.46 pounds, just 22 percent of the estimated average. Under the circumstances, a single haul would have yielded a better numerical sample than a weight sample.

Other Experience

The seining results from Brown's Lake were compared with those obtained on nine other lakes in southeastern Wisconsin in the spring of 1951. A substantial number of fish was caught in each, and the density was 4.1 to 22.8 (a median of 7.5). Though this density is less than that encountered on Brown's Lake, most of the range falls within the Brown's Lake range.

Minnesota has engaged in considerable seining for lake surveys (Moyle, Kuehn, and Burrows 1950). In 55 lakes where largemouth bass were captured, the average density reported was 8.5 pounds per acre. Although these data cannot be converted to numbers of fish, the weight density is about the same as encountered in southern Wisconsin. Moyle, Kuehn, and Burrows wrote (1950: 164): "Since most of the lakes in this series are shallow and are usually more than two-thirds littoral area, it is likely that the seining data give a fair approximation of the real size and structure of the fish populations sampled."

Fredin (1950), while attempting to sample the largemouth bass populations in a number of farm ponds in Iowa by using a 60- to 70-foot seine, was most disturbed by the mechanics of capture. Nevertheless, despite considerable difficulty, he was able to catch between 14 and 100 percent of the estimated population (a median of 41 to 45 percent) in 10 different situations. No doubt, when such a short seine was used, largemouth bass quickly sensed the need for escape.

Cooper (1952) in Michigan used trap nets to capture largemouth bass, and Gerking (1953) in Indiana used wire traps. Experience in Wisconsin has generally shown both these types of gear to be unsatisfactory for sampling largemouth bass.

Summary

Use of a seine 2,000 feet in length proved to be a successful method of capturing largemouth bass in the littoral zone of Brown's Lake. Seine hauls made anywhere within this 396-acre basin captured largemouth bass, although considerable mechanical difficulty in handling the net was encountered. The encircled fish

moved well ahead of the seine and did not attempt to escape until they were crowded into a small area.

The results from each of these seine hauls showed (1) that the size of fish and the pounds per acre varied considerably from one seining site to another, and (2) that the numbers of fish captured per unit of area varied with the seining site, though not so greatly as the weight and size of individuals. It is estimated that each haul captured approximately half of the number of fish present in the area covered. There was unequal distribution of year classes around the basin of this 396-acre lake. However, individuals (or small schools) appeared to be well scattered, because no seine haul captured more than 88 percent nor less than 34 percent of the average density.

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ADVANCED TRAINING COURSE FOR AQUATIC BIOLOGISTS

The Public Health Service will present at the Robert A. Taft Sanitary Engineering Center in Cincinnati, May 22-25, 1956, an advanced training course for aquatic biologists interested in water supply and water pollution problems. The course will feature the latest data and developments in the application of biological techniques to the study of water supplies and polluted waters. The course is available to professional and advanced technical personnel dealing with aquatic biology in industry; state, county, and municipal health departments; fish and game agencies; water supply and water pollution-control agencies; colleges and universities; research institutions; and other organizations.

For application blanks and further information, write to:

The Robert A. Taft Sanitary Engineering Center (Attention: Chief, Training Program), Cincinnati 26, Ohio.

A Minneapolis grocery-store manager holds lobsters about a week in a refrigerated (40° F.) tank containing 45 gallons of water, 18 pounds of commercial sea-water salts (making a 5-percent solution), and 2 spoonfuls of a commercial chlorine remover.

INCIDENCE OF B-COMPLEX AVITAMINOSIS AMONG COMMON CARP REARED IN TROUGHS

A. R. K. Zobairi
Superintendent of Fisheries for East Bengal
Dacca, Pakistan

NUTRITIONAL RESEARCH ON TROUT AND SALMON has made great progress, during the last decade, in determining the vitamin requirements. Very little work has been done, however, on the warm-water fishes, particularly the cyprinids. Investigations, though of a preliminary nature, were therefore undertaken to fill this gap. In the present article the writer describes observations on the incidence of avitaminosis due to deficiency of some members of the vitamin-B group among common carp (Cyprinus carpio Linnaeus) reared in indoor troughs on a diet of peanut meal and fish meal.

Material and Methods

Feeding experiments were conducted in stainless-steel troughs (7 feet by 1 foot by 0.8 foot) inside the fishery laboratory of the Alabama Polytechnic Institute at Auburn, Alabama, for 36 weeks. The fish used were fingerlings of the common carp, the weights of which ranged from 19.7 to 34.0 grams. The fish were fed selected diets, including 10 parts of peanut meal to 1 part of fish meal, at rates of 1.0, 2.0, 2.5, 5.0, and 7.0 percent of body weight per day. Feeding was done once every day in the forenoon, and the fish were weighed once every week for a record of their weekly growth.

The troughs were supplied with water tapped through galvanized-iron pipes from the Auburn city water supply. Sodium thiosulfate was added to the inflowing water to eliminate the chlorine during periods when chemical analysis showed its presence. Feeding was done in a temperature range of 80.0° to 86.0° F. The flow was adjusted so as to replace all the water (28.3 gallons) in the troughs once every 42 to 56 minutes.

Avitaminosis Due to Diet of Peanut Meal and Fish Meal (10:1) Fed at Rate of 2.5 Percent of Body Weight per Day

Carp fingerlings that had an initial average weight of 31.0 grams were stocked at the rate of 20 per trough. These carp were fed a diet composed of 10 parts of commercial peanut meal and 1 part of fish meal, at the rate of 2.5 percent of body weight per day, for a total of 34 weeks.

After the fish had been on this diet for 180 days, they began showing unusual excitability and nervousness. Their fin membranes, particularly those of the dorsal fins, became studded with transparent bubbles. Three days later, three fish receiving this diet lost their equilibrium and lay on their sides at the bottom of the trough. They had difficulty in swimming: when they attempted to swim, they swam with bellies up. Their eyes were bloodshot. One fish had an opaque cornea.

In June 1955 Mr. Zobairi received a Ph.D. from Alabama Polytechnic Institute, where his training in aquatic biology and fish culture was part of the FOA's technical assistance program under which the Fish and Wildlife Service plans and supervises fishery training for foreign technicians.

The fin membranes began to disintegrate and tear off, leaving the upper extremities of the fin rays bare and frayed. The fish began to lose the mucus on the body, particularly on the lateral line, which became abnormally prominent.

The diseased fish were allowed to remain in this condition for 5 days more, after which they were removed to aquaria containing fresh water treated with acriflavine at a concentration of 1 p.p.m. The water in the aquaria was aerated by compressed air. The fish were immediately given an intraperitoneal injection of 5 milligrams of thiamine hydrochloride in 1 milliliter of distilled water. As no abatement of the disease was evident even 24 hours after the medication, the injection was repeated with a concentration of 2 milligrams of thiamine hydrochloride. One of the three fish that received these injections died 2 hours after the second injection was administered. The two surviving fish continued to show symptoms of the disease.

Four hours after being given the second injection of thiamine hydrochloride, the two surviving fish were given intraperitoneally an injection of vitamin B complex. This injection administered 1 milligram each of pyridoxine, folic acid, calcium pantothenate, riboflavine, and vitamin B_{12}, and 50 milligrams of choline in 1 milliliter of distilled water.

Fourteen hours after the injection of vitamin B complex was given, both fish had regained their balance and were swimming normally. The opaqueness of the cornea cleared up, and the eye appeared normal 3 hours later. The air bubbles in the fin membranes disappeared, and the membranes began to regenerate within about a week after the fish regained their equilibrium.

These fish were held in the aquaria for a further period of 2 weeks, during which they were continued on their old diet. They appeared perfectly normal. Then they were put back into the troughs from which they had come.

No further incidence of this disease appeared for 8 more weeks. The fish were feeding, but all except those that were treated for avitaminosis were extremely nervous. During the 34th week, all but five fish died suddenly without showing any symptoms of avitaminosis. This mortality was suspected of again being due to nutritional deficiency. The fish that survived developed a popeye condition in which their eyeballs protruded grotesquely.

One of the fish having the popeye condition was injected intraperitoneally with 1 milligram of riboflavine; and another of these was given an injection consisting of a mixture of 1 milligram each of pyridoxine, folic acid, and calcium pantothenate in 1 milliliter of distilled water. The three fish remaining were kept as checks.

In the fish that had received an injection of pyridoxine, folic acid, and calcium pantothenate, the eyeball receded and the eye looked normal 24 hours after the injection. The fish that had received an injection of riboflavine only, however, continued to have the popeye condition even after 24 hours. The condition persisted in the fish that had received no injection.

The fish that had received the riboflavine was given, 26 hours after that injection, an intraperitoneal injection of folic acid alone in a concentration of 1 milligram per milliliter of distilled water. The bulging-eye condition persisted.

The experiments had to be stopped at this stage because of lack of time.

Avitaminosis Due to Diet of Peanut Meal and Fish Meal (10:1) Fed at Rate of 5.0 Percent of Body Weight per Day

Carp fingerlings that had an average weight of 33.0 grams were stocked at the rate of 20 per trough. These carp were fed a diet consisting of 10 parts of commercial peanut meal and 1 part of fish meal, at the rate of 5.0 percent of body weight per day, for a total of 33 weeks. The average weight of fish nearly doubled during this period, but the fish were nervous and easily excited 25 weeks after the feeding experiments were begun.

At the beginning of the 29th week, all but two fish died suddenly. All the dead

fish had blood-shot eyes, bubbles in the fin membranes, and a hemorrhagelike appearance at the fin bases. Post-mortem examination of these fish did not reveal any other pathological condition.

The surviving two fish lost their balance very soon afterward and developed opaqueness in the cornea. They were removed to aquaria. One of the following mixed injections was given to each of these two fish:

(1)	Pyridoxine ----------	1 mg.
	Folic acid ----------	1 "
	Calcium pantothenate --	1 "
(2)	Riboflavine ----------	1 "
	Vitamin B_{12} ----------	1 "
	Choline ----------	50 "

Both fish regained their balance. Their eyes cleared and bubbles disappeared from the fin membranes in about 18 hours after the injections. The fish were then placed on their diet, which they ate readily.

A month later, one of the two fish that had received an injection of riboflavine-vitamin B_{12}-choline developed an opaque cornea again and became very nervous. Its dorsal fin began to disintegrate. Eventually the fish lost its equilibrium. At this stage the fish was injected intraperitoneally with a mixture of 1 milligram each of pyridoxine, folic acid, and calcium pantothenate. This fish regained its balance 12 hours after the injection. The dorsal fin membrane regenerated and the cornea cleared 6 days later. The fish gradually ceased to be excitable and nervous.

The experiments could not be continued.

Discussion

The utility of a diet of peanut meal and fish meal (10:1) as a balanced diet for carp is questionable. Although fairly good increments in growth were obtained on this diet by merely increasing the rate of feeding, the danger of introducing avitaminosis--characterized by loss of equilibrium, extreme nervousness, decay of fin membranes, opaqueness of cornea, and protrusion of eyeballs--cannot be overlooked.

When this diet was used at the 5.0 percent rate of feeding, the vitamin deficiency became so acute that the fish died suddenly. Fed this diet at the 2.5 percent rate, however, the fish--though exhibiting symptoms of avitaminosis--lived long enough for treatment. The reason for this appears to be that at higher rates of feeding the animal body builds up rapidly and in this process the B vitamins--which are also involved in the metabolism of food--are expended relatively faster than in fish that grow slowly. Eventually, if the diet is deficient in these vitamins, their acute shortage causes death.

Avitaminosis observed in the carp during these investigations apparently was due to a deficiency or total absence of one or more members of the vitamin B group. It is doubtful whether thiamine had any part in the inception of the type of avitaminosis observed, as the administration of this vitamin failed to cure or even to alleviate the disease.

As far as could be ascertained, pyridoxine, folic acid, calcium pantothenate, vitamin B_{12}, and choline were jointly or individually responsible for the cure or alleviation of the type of avitaminosis encountered. Which of these vitamins are specifically responsible (by reason of their absence from the diet) for causing the avitaminosis, and which of the two components of the diet contributed to this deficiency, are problems requiring further investigation.

The popeye condition that developed among the carp toward the end of the feeding experiments also appeared to be due to a deficiency of B-complex vitamins. The injection of riboflavine or folic acid alone did not cure the disease. The effect of pyridoxine and calcium pantothenate on the popeye disease of carp must be determined in further experimentation.

Summary

1. Experiments on feeds and rates of feeding for the common carp (Cyprinus carpio Linnaeus) in indoor troughs were conducted at a temperature range of 80° to 86° F. in the fishery laboratory of the

Alabama Polytechnic Institute at Auburn, Alabama.

2. A diet of peanut meal and fish meal (10:1), fed at the rates of 2.5 and 5.0 percent of body weight per day, produced avitaminosis -- characterized by extreme excitability and nervousness, loss of equilibrium, disintegration of fin membranes, and opaqueness of cornea--among the carp after about 180 days of feeding. The diseased fish recovered completely when injected intraperitoneally with a mixture of either pyridoxine, calcium pantothenate, and folic acid, or riboflavine, vitamin B_{12}, and choline in distilled water.

3. An injection of thiamine alone, even in a concentration of 5 milligrams, did not cure or alleviate avitaminosis.

4. The diet also caused popeye among the carp, a condition which was cured by injecting a mixture of pyridoxine, calcium pantothenate, and folic acid. Injections with riboflavine or folic acid alone did not cure this disease.

IMPROVED PLIERS FOR APPLYING RING TAGS

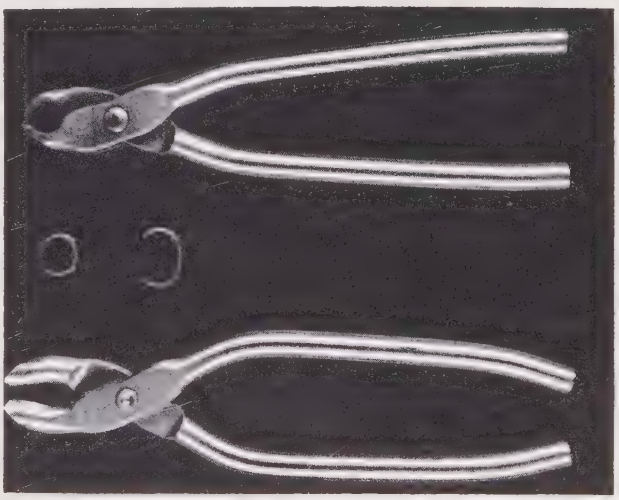
Starting with a pair of common hog-nosed pliers, Amos W. Horrocks, fishery technician of the New Jersey Division of Fish and Game, has prepared an efficient pair of pliers for the application of ring tags. Mr. Horrocks, who is stationed at the New Jersey State Fisheries Laboratory at Milltown, reports that the use of these pliers has greatly speeded up the tagging operations in that State during the past year.

"A rat-tailed file inserted in an electric drill," writes Mr. Horrocks," is used to alter the opening between the jaws of a pair of common hog-nosed pliers in such a way that this opening will accommodate the desired size of ring tag. The posterior margin of the circular opening should be half an inch from the center of the point of pivot on the pliers. The excess metal at the ends of both jaws is then ground or filed away to the desired diameter, about 3/32 inch.

"In order to have the tags overlap slightly after being crimped, one 'arm' of the pliers is held vertically on a solid surface and the top, or end, of the jaw is tapped lightly to offset it a little from the opposing jaw.

"It has also been found necessary to straighten the handles of the pliers to suit the individual user. In addition, a rubber band--long-wearing and replaced with a minimum of time and effort--may be wrapped around the base of the jaws to hold the tag in position without need for hand pressure.

"Another advantage of the redesigned pliers is the small size of the tool, as it may be inserted quickly and easily into the mouth of a small fish. It is seldom necessary to 'fight' the fish to get its mouth opened sufficiently to accommodate the pliers, and this will eliminate considerable rough handling."



(Photograph courtesy of Mr. Horrocks)

Tagging pliers (top) adapted from hog-nosed pliers (bottom) as used in installing auto-seat covers. The closed ring (center, left) shows how these pliers will crimp a ring tag.

HARVEST FROM AN EXPERIMENTAL ONE-ACRE SALT-WATER POND AT BEARS BLUFF LABORATORIES, SOUTH CAROLINA

G. Robert Lunz
Bears Bluff Laboratories
Wadmalaw Island, South Carolina

THE IMMINENCE OF HURRICANE DIANE in August 1955 made advisable the termination of experiments in one of the salt-water ponds at Bears Bluff Laboratories, Wadmalaw Island, South Carolina. This 1-acre pond, containing between 75,000 and 85,000 cubic feet of water, was drained on August 15.

The pond had been filled November 4, 1954. The automatic flap-valve floodgate was not screened. The elevation of the water in the pond had been kept at 5.8 feet above mean low water by using the 8-inch overflow pipe. Whenever the tide exceeded 5.8 feet, or whenever the pond had leaked below the level of the high tide in the adjacent creek, new water entered the pond through the automatic floodgate and/or the overflow. This occurred on 25 days between November 4, 1954, and August 15, 1955, with the new water entering on 3 days in every month but February and March. On this first filling, the gate would open wide enough to admit fish several inches long. Once the pond was filled, only the very small fish could enter, as the gate opened only half an inch or less.

This experimental pond was not stocked with any fishes, crabs, or shrimps, and was not fertilized between drainings.

During the period from December to August 15, the salinity and temperature of the water in the pond were as shown in table 1.

The majority of the fishes, shrimp, and crabs in the pond were collected during this draining. Small fishes (such as anchovy, Fundulus, and Cyprinidon sp.), shrimp of the genus Palaemonetes, and some juvenile blue crabs were not harvested. From 5 random samples of the fishes, their total number was calculated to be slightly in excess of 7,000 individuals. The number of crabs and shrimp, when added to this number of fish, brought the total population to about 9,500 individuals, which had a combined weight of slightly more than 400 pounds.

TABLE 1.--Temperature and salinity of a 1-acre salt-water pond at Bears Bluff Laboratories, December 1954 to August 15, 1955

Month	Temperature °C.			Salinity °/oo		
	Maximum	Minimum	Mean	Maximum	Minimum	Mean
December	16.5	7.0	11.7	28.2	18.0	25.4
January	15.5	8.0	11.2	30.8	24.8	24.3
February	16.0	8.0	13.3	25.8	22.8	25.2
March	24.0	13.0	20.2	31.0	25.6	27.4
April	28.0	19.0	23.7	30.6	24.0	27.5
May	33.0	25.0	29.2	29.4	25.4	27.8
June	32.0	25.0	29.5	33.2	17.6	27.6
July	35.0	32.0	33.6	26.2	23.3	24.4
August	36.0	28.0	32.5	27.0	25.0	25.1

TABLE 2.--Detailed harvest from a 1-acre experimental salt-water pond at Bears Bluff Laboratories, November 4, 1954, to August 15, 1955

Species	Size in inches			Number	Percent total	Weight		Percent total	Remarks
	Min.	Max.	Mode			Pounds	Ounces		
Mullet (Mugil)----------	2.75	6.50	6.00	1,907	20.1	209	12.75	51.3	First noted in pond on Jan. 30, 1955, at size about 20 mm.
Spot (Leiostomus)----------	3.00	5.50	4- 4.50	2,441	25.7	67	7.25	16.5	Ripe females noted in adjacent areas in Oct., Nov., and Dec.
Yellowtail (Bairdella)------	1.50	4.50	3- 3.50 4- 4.50	2,596	27.4	43	15.50	10.7	Ripe females noted in adjacent waters in April, May, and June.
Menhaden (Brevoortia)-------	2.00	6.00	6.00	195	2.1	28	5.00	6.9	
Ten-pounder (Elops)---------	8.00	11.00	10.25	63	.6	19	12.00	4.8	
Mojarra (Eucinostomus)------	2.50	3.00	2.75	24	.2	0	11.75	.2	
Croaker (Micropogon)--------	7.50	8.50	-------	2	-------	0	9.00	.1	Presumably entered as 4- to 5-inch fish, Nov. 4 or 5, 1954.
Channel bass (Sciaenops)----	----	-----	14.00	1	-------	1	4.00	.3	Presumably entered as 6- to 7-inch fish, Nov. 4, 1954.
Brown shrimp (Palaemonetes aztecus)	4.50	7.00	5.75	370	3.9	15	10.75	3.8	2-inch size appeared in nearby creeks and waterways by early May.
White shrimp (Palaemonetes setiferus)	2.00	3.75	2.75	1,851	19.5	11	9.00	2.8	2-inch size appeared in nearby creeks and waterways by early July.
Blue crab (Callinectes sapidus)	5.00	7.00	6.00	33	.3	9	4.50	2.2	
Totals----------				9,483	99.8	408	5.50	99.6	

This weight exceeded by about 100 pounds the maximum figure that Lunz (1951) gave for 5 drainings of the pond. However, as the records and measurements then published by Lunz did not include fishes less than 5 inches in length and generally excluded the weight of shrimp, the production in this pond during 8.5 months may not have been higher than the production recorded in previous years. Table 2 shows the complete picture of the harvest.

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TREATMENT OF TRICHODINID INFECTIONS OF CHINOOK SALMON FINGERLINGS

Trichodinid infections were the cause of considerable mortality among fingerling fall chinook salmon during the fall of 1955. Studies made by Harlan E. Johnson of the U. S. Fish and Wildlife Service revealed, however, that treatments with formalin or pyridylmercuric acetate resulted in very obvious reductions in this mortality.

On one group of fall chinook salmon fingerlings (of the 1954 brood), the parasite Trichodina was found early in September. Infected fish had light-colored areas on their bodies, frequently posterior to the dorsal fin and often surrounding the anal fin and vent. Some fish also showed reddening or small hemorrhagic areas. All such fish examined had a heavy infestation of Trichodina on the body surface. During October, when 500,000 were held in 10 raceways, the number of deaths rose to 400 daily. Between October 26 and November 2, however, 8 of the ponds received a treatment with formalin at a concentration of 1:4,700 for 1 hour, and 2 ponds received a treatment with pyridylmercuric acetate at a concentration of 1:500,000 for 1 hour. On November 4, mortalities numbered only 21; thereafter, losses averaged about 5 fish per day in the entire lot.

"PMA is more expensive but easier to use," wrote Mr. Johnson, "and there is no danger of developing lethal concentrations in areas of the ponds--as sometimes happens with formalin."

At a second hatchery, where 400,000 fall chinook salmon fingerlings (of the 1954 brood) were being held over winter in four ponds, trichodinasis had become far advanced before the presence of this infection was detected. These salmon had had kidney disease since September. To check the kidney disease, the salmon in three of the ponds were fed a sulfa preparation. As the condition of these salmon receiving the sulfa showed improvement, treatment with this drug was eventually extended to include the salmon held in the fourth, or control, pond. In the fourth pond, however, the sulfa apparently produced no beneficial results, as there was no reduction in the mortality. Early in December there was a considerable increase in mortality among these salmon, especially among those held in the fourth, or control, pond. On December 7 it was found that the fish were heavily infected with Trichodina, and that many of the fish had light-colored lesions just anterior to the dorsal fin. The four ponds of salmon were treated at once with pyridylmercuric acetate at a concentration of 1:333,000. The results were striking: whereas the mortalities during the week prior to this treatment had numbered between 1,000 and 1,400 daily, the total of mortalities in this lot of salmon on December 12 was 34.

Reporting on this latter trial of pyridylmercuric acetate, Mr. Johnson concluded:

"It may be that these young chinook salmon have been saved from the external parasite only to succumb eventually to kidney disease, but for the present the loss pattern is encouraging."

MIGRATION BEHAVIOR OF A DWARF SUCKER WITH AN INJURED BRAIN

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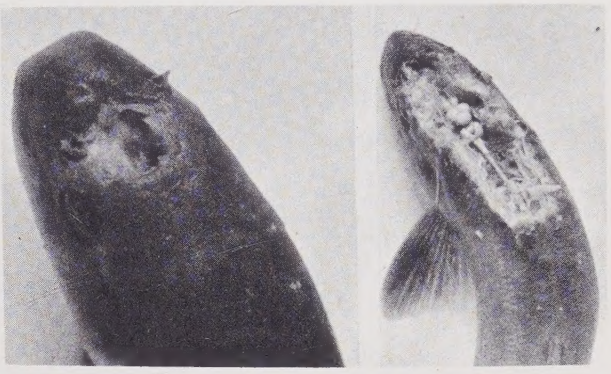
THIS ACCOUNT is based on a 5.5-inch dwarf sucker (Catostomus commersonni utawana Mather), a breeding male taken from the spawning grounds of this species in the North Inlet of Wolf Lake, at the Huntington Forest, Newcomb, New York.

As reported by Dence (1948), this species spends most of its life in deep water. Upon reaching sexual maturity, however, it annually migrates from lakes into suitable inlets to spawn. Spawning proceeds rapidly, and the spent suckers return to the lake immediately thereafter. Although there are individual variations in the precise spawning date, generally the spread is in a 2-week period beginning late in May and extending about a week into June.

The specimen discussed here was taken on the breeding grounds on June 27, 1944, about 2 weeks after the others had returned to the lake. The most likely explanation may be found in the fact that the fish received an injury involving the forebrain. The cause of the injury is not definitely known--though it appeared to be mechanical, resulting from the bill of a predatory bird--but the fact remains that all tissue in an area 6 millimeters wide and 9 millimeters long on top of the head, between the eyes and extending to and involving the brain, was missing. The fish had lost both olfactory nerves, as well as all of the left and part of the right olfactory lobes.

The injury did not appear to affect the general health and vigor of the victim. Its failure to return to the lake seemingly was the only abnormal reaction. Hasler and Wisby (1951) mentioned the possibility that



Dwarf suckers: at left, the injured fish; at right, dissection of the brain of a normal fish.

(Photographs courtesy of the author)

the sense of smell plays an important role in directing fishes during migration. They stated (1951: 223) that:

> ... The primitive character of this sensory system, its evolutionary constancy, its extreme sensitivity in comparison to other receptor processes, and its capacity to serve as a memory-evoking mechanism, all point to a working hypothesis -- that olfactory stimuli may be factors in the homing of migrating fishes.

The behavior of the injured dwarf sucker substantiated their theory in a unique manner. However, it is quite remarkable that the injury was so perfectly inflicted in the precise area, and that the victim was able to survive sufficiently long to demonstrate its reaction

to the loss of the olfactory portion of the brain.

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TROUT AND GRAYLING POPULATIONS IN GREBE LAKE

Biologists assigned to the project by the U. S. Fish and Wildlife Service recently completed their study of the trout and grayling data obtained during 1955 from Grebe Lake in Yellowstone National Park. The program in 1955 generally followed the operational patterns established for this study in the 2 preceding years.

The spawning runs of grayling into trapped streams numbered 4,977--or 66 percent and 75 percent of the 1954 and 1953 counts, respectively. The grayling eggs that were planted in Grebe Lake in 1955 numbered 276,065, of which 45,195 eggs were allotted to planned experiments. More than half of the eyed eggs that were planted in a Grebe Lake tributary entered the lake as fry, and the planting in the lake itself produced comparable results. An estimate of the abundance of fingerlings--an estimate made in September by sampling with seines--was about 25 percent lower than the estimate secured on the basis of mortality estimates.

Thermal characteristics of the lake and certain tributaries were measured. The surface temperature of Grebe Lake reached daily maxima of 70° F. from the middle of July through early September. All the stream temperatures averaged less than 60° F. throughout the season.

Fishing accounted for the harvest of an estimated 1,611 grayling and 467 trout from Grebe Lake. This estimate of the harvest was based on a voluntary creel census in which more than 40 percent of the fishermen reported their catch. The figures for 1955 exceeded the catch estimates for 1953 and 1954, although the degree of fisherman success remained stable. During 1955 the fishing pressure (which was almost double the pressure on this lake in previous years) was responsible for the increase in total catch.

The population estimate for grayling in 1955 was comparable to estimates made in the previous 2 years. The population estimate for trout in 1955, however, indicated that there had been a significant decrease in the numbers of this species. (See table.)

Grayling and trout population estimates for Grebe Lake

Species	1953	1954	1955
Grayling	25,793	30,665	26,324
Trout	2,242	3,344	1,228

The studies completed during the past 3 years indicate that the trout and grayling populations of Grebe Lake are in a healthy state of equilibrium. Apparently there is no evidence of serious competition between the two species. The data suggest that although the present management of the lake is sound, a larger harvest of the grayling could be taken without causing any harm to that population.

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